

Nisqually River Level I Watershed Assessment (WRIA 11)

SUMMARY REPORT

Prepared for:

Nisqually Watershed
Planning Group

Prepared by:

Watershed Professionals Network, llc
Envirovision
GeoEngineers

WPN
watershed
professionals
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July 2002

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Definitions

303(d) List: The Clean Water Act mandates that a list of water bodies that do not meet water quality standards (based on documented violations of water quality standards) be kept by the state. This mandate is written in Section 303(d) of the Act; hence the list is generally referred to as the 303(d) list.

Acre-feet: A measure of water volume typically used to describe agricultural water use. Also used as a measure of the volume of water in reservoirs. An Acre-foot is the amount of water needed to cover 1 acre of land a foot deep and is equivalent to 325,851 gallons.

cfs: Cubic feet per second. This is a measure of stream flow that is estimated as the number of cubic feet of water passing a point on the stream each second. One cfs is equivalent to 7.48 gallons per second.

Ecology: Washington Department of Ecology

EPA: U.S. Environmental Protection Agency

Exempt well: A well that is not required to have a water right. Most wells serving 6 or fewer homes are exempt.

gcd: Gallons per capita per day or the average number of gallons used by each person per day.

Geohydrologic unit: A geologic formation or group of formations with similar characteristics affecting groundwater aquifers and groundwater movement.

Net depletion: This is the volume of water that is withdrawn from a stream or groundwater source that is used up. It does not include any portion of the withdrawn water that is eventually returned to the water source (return flow).

Non-consumptive water use: Water that is diverted for a use that does consume any of the volume of water diverted. All of the water that is diverted is returned. For example, fish hatcheries often divert water. That water passes through the hatchery and then is returned to the stream with no reduction in total volume of water. Hence, no water is consumed.

Return flow: Return flow is the volume of water that was withdrawn from surface or groundwater sources that was subsequently returned to the stream. For example, some portion of the water used for irrigation typically runs off to a stream or percolates back into the groundwater. Likewise, some portion of the water that is treated in septic systems eventually makes its way back into the groundwater.

TMDL: Total Maximum Daily Load. This term is used in plans that address maintaining and/or improving water quality. The Total Maximum Daily Load was originally used as the total volume of daily pollutant inputs that are allowed. More recently, the term has become synonymous with the actual water quality plans developed by the U.S. Environmental Protection Agency and the Washington State Department of Ecology in which the total allowable inputs are evaluated and set.

USGS: United States Geological Survey. Agency within the Department of Interior responsible for, among other things, collecting and distributing streamflow data for the nation. Also a source of information regarding water use and water quality.

Nisqually Level 1 Watershed Analysis

SUMMARY

INTRODUCTION

The Watershed Management Act (RCW 90.82) was established in 1998 to address the diminishing water availability and quality, and the loss of critical habitat for fish and wildlife in the state. The bill provides a framework for local citizens, tribes, and state and local agencies to work together to develop watershed management plans for entire watersheds. As part of this process, a Watershed Assessment must be completed for each Water Resource Inventory Areas (WRIA) to evaluate water supply and water use.

Watershed assessments are completed in two parts, referred to as the Level I and Level II assessments. The Level I assessment provides an assessment based on currently available information. Recommendations are made regarding data gaps and information needed to improve the understanding of water supply needs, instream flows, and water quality. These recommendations focus on information that is likely to affect the interpretation of data or provide information necessary to support basin planning efforts. As needed, a Level II assessment may be completed to fill those data gaps.

A Level I assessment was completed for this Lower Nisqually Watershed (WPN 2002) under the direction of the Lower Nisqually Watershed Planning Group¹. This document provides a summary of the information contained in that Level I assessment. This summary is generally organized by subbasin. Stream flows, groundwater sources, fish habitat, water rights and water use, water quality, and basin specific recommendations are covered for each subbasin. Prior to the subbasin summaries, generalized information regarding the watershed as a whole is provided, including an explanation of some general concepts that are important for understanding the data presented.

Throughout this document, page numbers for references in the full report are provided. These will help guide the reader to the appropriate page of the Watershed Assessment Report where additional information can be found. Pagination in the Watershed Assessment uses a format displaying first the section number followed by the page. For instance, 2-14 is Section 2, page 14 and 5.2-18 refers to Section 5.2, page 18.

Also found throughout this report are sentences in blue font. The blue font is used to emphasize discussions of uncertainty regarding data, interpretation of data, or conclusions. Not all areas of uncertainty are represented in this document. At the end of the watershed overview and each of the subbasin sections, a discussion of Level II recommendations is provided. This discussion focuses on high priority

¹ Members include Washington Department of Ecology, Thurston County, Pierce County, Cities of Yelm, Olympia, Eatonville, Lacey, Nisqually River Council, Elbe Water District, Graham Hill Mutual Water

recommendations. Additional information can be found in Chapter 7 of the Level I watershed analysis report.

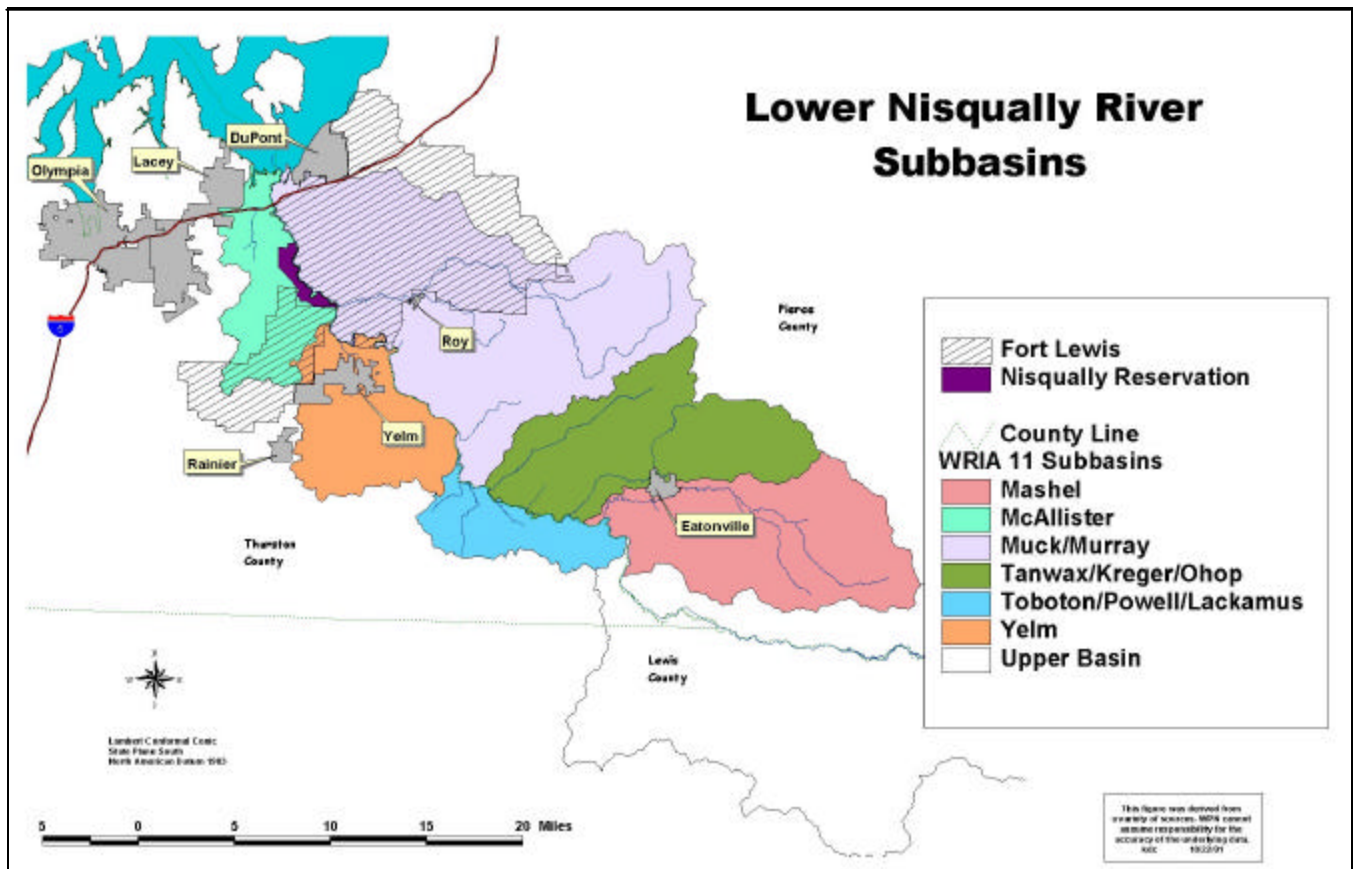


Figure 1. Location and subbasins in the Lower Nisqually River Watershed

WATERSHED OVERVIEW AND BASINWIDE FINDINGS

The study area includes the Lower Nisqually watershed of WRIA 11 located in Pierce and Thurston Counties, Washington (Figure 1). Nisqually River has its origin on Mount Rainier and drains to Puget Sound. The portion of the Nisqually River basin covered by this assessment includes the lower portion, downstream of the LaGrande dam. The lower Nisqually River watershed has been subdivided into six subbasins (Table 1), ranging in size from 39.2 square miles to 181.5 square miles (Page 1-3). Subbasin boundaries were based upon surface topography and do not necessarily reflect groundwater boundaries.

Table 1. Subbasin size (page 1-3).

Subbasin Name	Area (mi ²)
1. McAllister	39.2
2. Muck/Murray	181.5
3. Yelm	52.0
4. Toboton/Power/Lackamas	27.8
5. Tanwax/Kreger/Ohop	82.1
6. Mashel	89.2
Lower basin total	471.8

HISTORY AND LAND USE

The Lower Nisqually River watershed was one of the first areas of settlement in the Puget Sound area. The upper portion of Ohop Creek was diverted into the Puyallup basin in 1889, resulting in a roughly 30% reduction in stream flow in that basin.

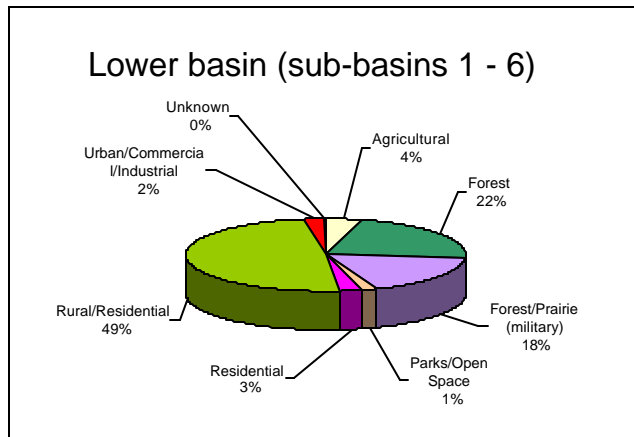


Figure 2. Land use in the Lower Nisqually River Watershed

The LaGrande hydroelectric project was completed in 1910 and reconstructed in 1942-44. The Yelm Hydroelectric project was completed in 1929. Currently, there are 18 documented dams in the lower watershed, including Alder dam, La Grande dam, Central Diversion Dam, McAllister Springs, and several dams forming large lakes.

Today, land use in the watershed is primarily rural residential (Page 2-24, Figure 2). Other major land uses include

forest/prairie habitat, forests, and agricultural areas. The communities of Lacey, DuPont, Yelm, Roy, and Eatonville are located, at least partially, within the watershed.

TOPOGRAPHY, GEOLOGY, AND SOILS

The lower watershed ranges in elevation from 0 to 4845 feet (Page 2-3), although the majority of the basin lies at an elevation less than 1000 feet high. The steepest subbasins in the watershed are the Mashel and the Tanwax/Kreger/Ohop subbasins. The McAllister, Muck/Murray, and Yelm subbasins are the flattest.

The geology in the watershed has been strongly influenced by a number of glacial periods (Page 2-10). Continental glaciers advanced into Pierce and Thurston Counties several times during the Pleistocene Epoch, the last of which began approximately 15,000 years ago. As a result of these repeated glacial advances and retreats, most of the western portion of lower Nisqually watershed is covered by as much as 2,000 feet of unconsolidated deposits of boulders, rock, and soil (Figure 3). Water percolates easily through these materials, hence the distribution of these deposits affect the depth and extent of groundwater in the basin. Large areas of the eastern portion the watershed were not covered by glacial ice. The geology in these areas generally consists of sedimentary and volcanic rock. Water runs off more quickly in these areas, and large aquifers are less common.

Properties of soils influence the movement of water through and within the soil layers. The majority of the soils in the upper part of the study area are moderately porous (page 2-7). Soils in the lower basin are range from highly porous to relatively resistant to the infiltration of water.

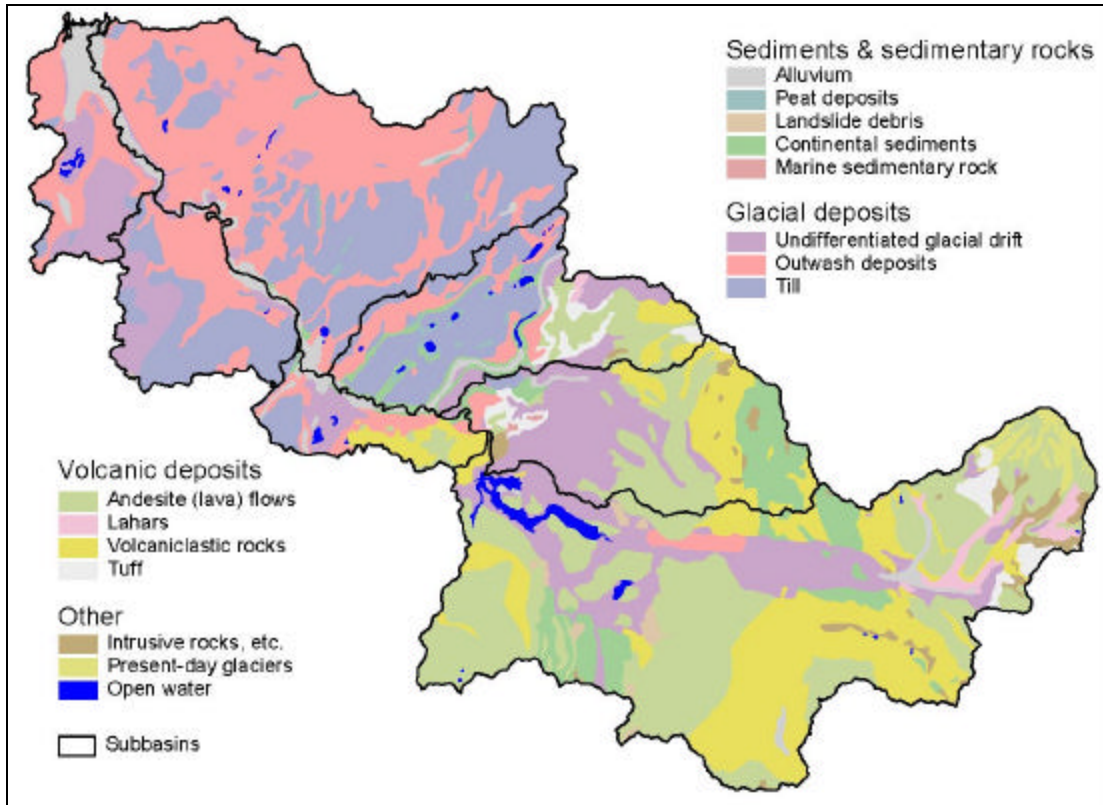


Figure 3. Surficial geology of the Nisqually Basin. (Page 2-9).

PRECIPITATION

Precipitation (rain and snow) strongly influences stream flow in the Lower Nisqually Watershed. Mean annual precipitation within the basin generally increases as elevation increases (page 2-14, Figure 4). On average, the lower portions of the watershed receive from 33 to 50 inches of precipitation per year. The higher portions of the watershed receive greater than 70 inches of precipitation annually. The wettest months are November through January and the driest months are June, July, and August. Precipitation typically cycles over periods of decades from warm/dry periods to wet/cool periods and back again. The climatic cycles are important in interpreting data on water availability. Historically, cool/wet years included the periods from 1890 to 1924 and 1947 to 1976 (page 2-19). Warm/dry years occurred from 1925 to 1946 and 1977 to 1995. Although the data is somewhat inconclusive, it appears that we have been moving into another cool/wet period since 1995.

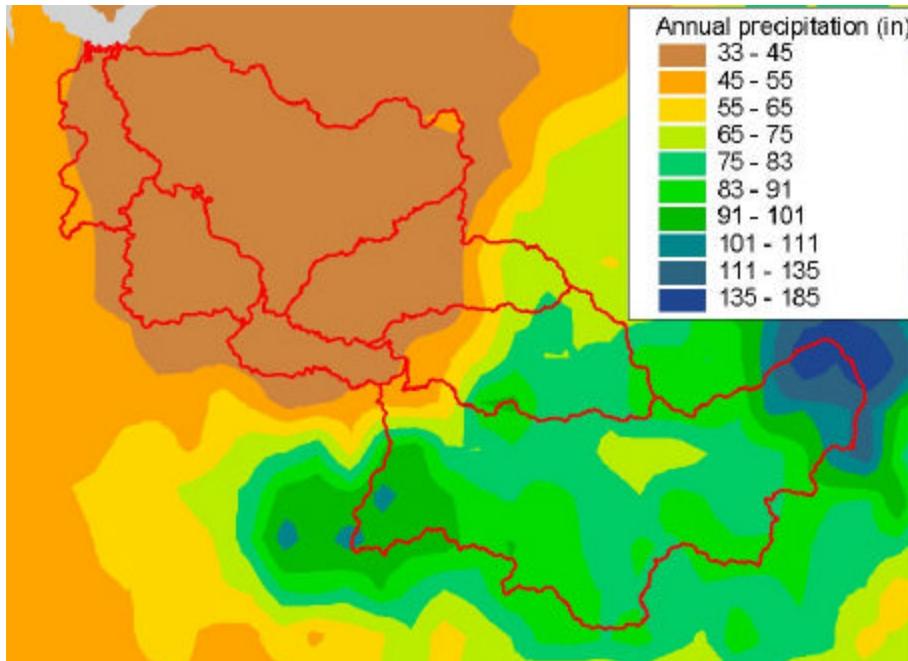


Figure 4. Mean annual precipitation (inches) for the period 1961-1990 (Page 2-15).

STREAM FLOW

Twenty-one USGS stream gages are, or were, located within the Nisqually basin (page 5.1-1). Some gages are inactive and several contain records that are too short to be of any practical use. The seven gages that were most representative of conditions in the watershed were used to support the assessment of stream flow (page 5.1-4).

Estimates of streamflow were made for each subbasin, and for representative locations along the mainstem of the Nisqually River. *The reader is cautioned that the flows depicted do not represent “natural” or pre settlement conditions (page 5.1-3). All gage records are affected by upstream land use, including impoundments, water diversions, and water withdrawals. “Natural” flows typically are higher than those depicted.*

Stream flows are normally expressed in terms of cubic feet per second (cfs). This is the number of cubic feet passing a point in the stream channel each second. Average and low stream flows are represented in this analysis using two different measures. The first is the 50% exceedance flow. This is the flow that is exceeded 50% of the time and corresponds roughly to average flow. The other measure used is the 90% exceedance flow. This is the flow that is exceeded 90% of the time and represents a typical low flow condition.

Flows from tributaries in the six subbasins in the lower Nisqually Watershed contribute roughly 40% of the total flow in the lower mainstem of the Nisqually River. The balance of the mainstem flow originates in the upper Nisqually watershed. The subbasins with the highest monthly and annual flows are Mashel, Muck/Murray, and Tanwax/Kreger/Ohop (Figure 5) (page 5.1-10). These are also the largest subbasins.

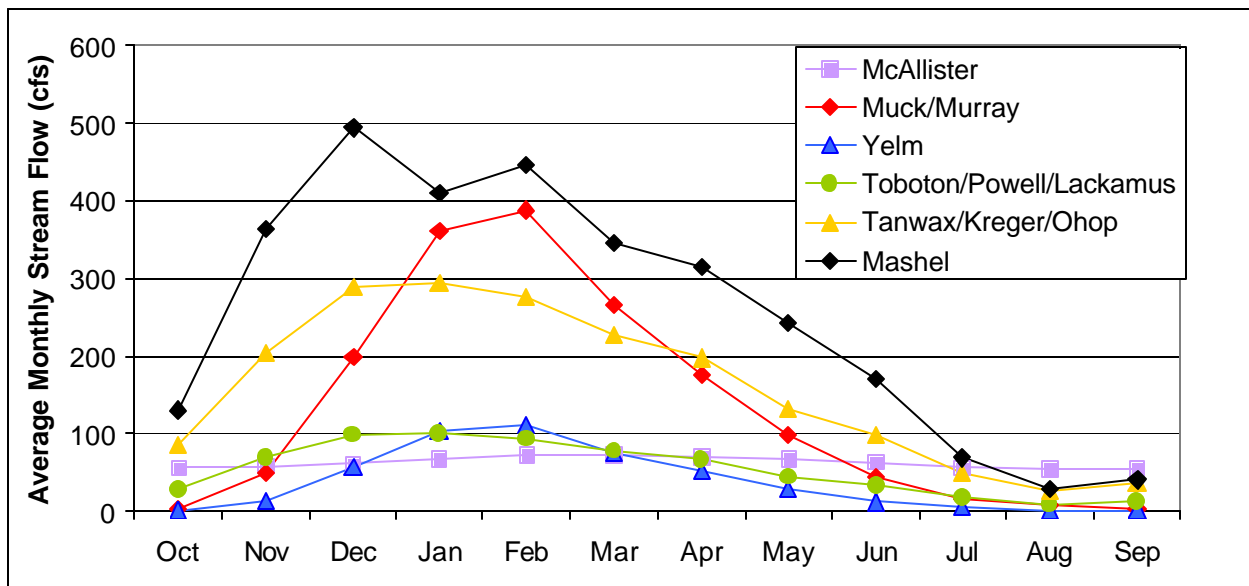


Figure 5. Average monthly (50% exceedance) flows (cfs) in each of the subbasins (page 5.1-13).

INSTREAM FLOW REQUIREMENTS

The Department of Ecology, under the Water Resources Management Program (WAC 173-500) is authorized, among other things, to “...establish flows on perennial streams of the state in amounts necessary to provide for preservation of wildlife, fish, scenic, aesthetic, and other environmental values, and navigational values...” and “...set forth streams closed to further appropriation” (Ecology 2000). As of 1988, 20 tributaries and lakes and 2 segments of the Nisqually mainstem have been closed at least seasonally to further allocation (pages 3-21, 3-22). These closures cover a large percentage of the watershed. The mainstem closures include the bypass reach and the mid reach, both of which are closed June 1 to October 31.

Additionally, minimum instream flows have been set by Ecology for five areas: three control points on the mainstem, the bypass reach, and one point on the Mashel River (page 3-22; Figure 6). Additional minimum instream flow requirements are in place for the bypass reach and the reach below LaGrande dam, which were set by the Federal Energy Regulatory Commission (FERC) as a requirement for the operations of the dam (Table 2).

Table 2. Minimum instream flows set by FERC as a condition of the permit to operate the LaGrande dam.

<i>Date</i>	<i>Bypass Flow (cfs)</i>	<i>Mainstem Flow (cfs)</i>
<i>October 1 - December 15</i>	<i>550</i>	<i>700</i>
<i>December 16 - May 31</i>	<i>600</i>	<i>900</i>
<i>June 1 - July 31</i>	<i>500</i>	<i>750</i>
<i>August 1 - September 30</i>	<i>370</i>	<i>575</i>

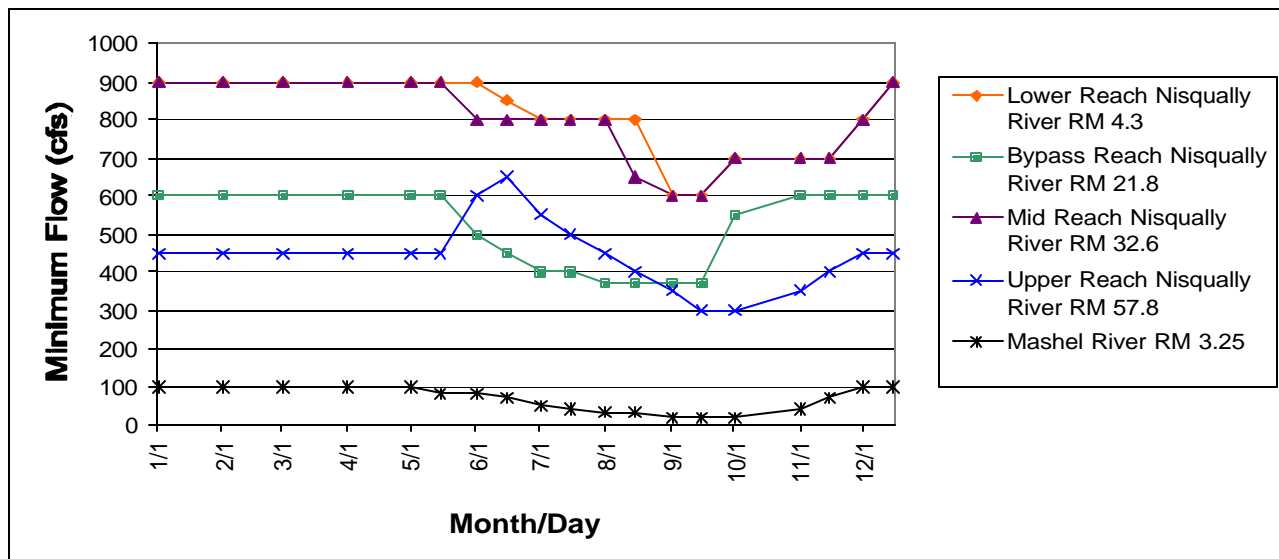


Figure 6. Required minimum instream flows for three points on the mainstem Nisqually River, the bypass reach and a point on the Mashel River.

The instream flows specified in the permit to operate the dam are based on intensive studies and are believed to be a good estimate of fish habitat needs. [The other instream flows and closures are based on poorer information. Review of these closures and instream flows may be in order.](#)

GROUNDWATER RESOURCES

[Information regarding groundwater resources in the watershed is limited.](#) The Level I analysis relied upon data from the Department of Ecology (Ecology), a groundwater model completed by the USGS, a conceptual groundwater model developed by AGI, information from major water purveyors, the Ecology water well database, and data from the cities in the watershed, the Department of Natural Resources, and other state

agencies. Information on the extent and volume of aquifers, however, relied primarily on the USGS model (page 5.2-1).

It should be noted that the USGS model was a very simplistic model. The USGS employed several simplifying assumptions in their model that recent information suggests may not be representative of the actual groundwater situation in the basin (page 5.2-2). The model was only able to account for a small portion of the total estimated groundwater recharge in the area. Hence, there is a great deal of uncertainty regarding the accuracy of the results of this modeling effort. The watershed assessment includes the best estimates of aquifer extent, volume, and flow possible given this information. It is highly likely that the geologic/hydrogeologic conditions present in the lower Nisqually watershed are significantly more complex than assumed in the USGS model. Currently, Camp, Dresser & McKee (CDM) is developing an update on the groundwater model that is expected to be a significant improvement over the older version. Once this modeling effort is complete, the model should be reviewed and information regarding groundwater resources presented in the watershed assessment should be updated as appropriate.

Major Geohydrologic Units

Seven major geohydrologic units (areas with similar groundwater related characteristics) have been described that affect the depth, distribution, and quantity of groundwater (page 5.2-8). The reader should note that often these units lie at depth in positions where groundwater flow may move between subbasins or even between the Nisqually watershed and adjacent watersheds. *The estimated location of these units in the watershed can be inferred from well logs and other information, however the precise location is unknown.*

Two of these geohydrologic units were combined for the purposes of the Level I assessment because they are very similar. These two units, known as the Holocene alluvium and Vashon recessional outwash, are relatively shallow and are typically 10 to 40 feet thick (page 5.2-8). They are found under the Tanwax/Kreger/Ohop, Toboton/Powell/Lackamas, and Mashel subbasins, where they can be a significant source of water. They are also present around the Nisqually delta. Water generally flows freely through these deposits, however, the presence of fine-grained sediment in these deposits can act to restrict flow of water. This may especially be true of the delta deposits. *The degree to which flow is restricted by these fine-grained sediments is currently unknown.*

Another geohydrologic unit, known as the Vashon till, lies at or near the ground surface in the northwest portion of the watershed. This unit is a poor source of water (page 5.2-11). The Kitsap formation is another low unit with low permeability (page 5.2-11). It typically is found below the Vashon till and can be between 20 and 150 feet thick. The Vashon advance outwash geohydrologic unit is an important aquifer in the watershed. Numerous domestic wells have been completed in this unit. These wells tend to have moderate to high yield (page 5.2-11). The unit is generally between 10 and 45 feet thick and is located between 50 and 400 feet above sea level.

There is a set of sediment deposits located beneath most of the McAllister, Muck/Murray, and Yelm subbasins that have been coded as Qc (page 5.2-11). This unit is likely beneath portions of the Toboton/Powell/Lackamas and Tanwax/Kreger/Ohop subbasins as well. Numerous highly productive wells have been completed in this unit.

The final major hydrogeologic unit in the watershed is the unconsolidated glacial and non-glacial sediments, which have been coded TQu (page 5.2-11). These sediments are located beneath the Qc unit. Hundreds of wells apparently tap this unit throughout Thurston County; however, the unit has not been extensively developed in the watershed. Groundwater tends to be confined in this unit. The unit can be several thousand feet thick in the northwestern portion of the watershed.

The entire watershed is underlain by bedrock. Small quantities of groundwater can be obtained from fractures and joints in this rock (page 5.2-12). Yield is generally poor, but the unit can be an important source of domestic waters in some areas, particularly in the Toboton/Powell/Lackamas, Tanwax/Kreger/Ohop, and Mashel subbasins, where the more permeable water bearing sediments are not present.

As was mentioned earlier, much of the watershed is underlain by a substantial thickness of permeable sediments containing several aquifers (page 5.2-12). Many of these sediment layers and aquifers extend beneath portions of adjacent watersheds to the north and south. Therefore, it is highly likely that some natural groundwater exchange occurs between these watersheds. [The extent of the exchange of water between the watersheds is currently unknown, although there is evidence that it may be substantial.](#)

Groundwater Recharge

Recharge to the groundwater system in the study area is primarily through the infiltration of precipitation and secondarily as seepage from surface water (lakes, ponds and streams), and from anthropogenic affects (septic systems, irrigation return flow, water reuse, etc) (page 5.2-12). Estimated recharge through precipitation ranges from 0 to over 80 inches per year (page 5.2-15). The highest recharge areas are located in the upper basin where rainfall is also higher. [The rates of recharge are uncertain in most areas \(page 5.2-17\).](#)

Most streams are fed by groundwater; hence, the water leaving the groundwater system to become surface water exceeds the amount of water seeping out of streams and lakes and into the groundwater system (pages 5.2-16). In the Nisqually watershed, however, there are numerous areas where surface water seeps into the groundwater system. This is particularly true in the lower basin where the lower sections of a number of streams go dry or nearly dry in summer. These streams flow over the highly permeable unconsolidated deposits discussed earlier.

The City of Yelm currently operates a wastewater reclamation project that returns Class A reclaimed water to surface water and groundwater systems in the immediate vicinity of the City (page 5.2-17). The water reclamation project provides approximately 56 acre-feet of increased groundwater recharge annually to the shallow aquifer system in the

immediate vicinity of the City. In addition, roughly 168 acre-feet per year of treated wastewater is used to augment surface water flows and for summer irrigation.

Human induced recharge also occurs in many locations of the WRIA from septic system, irrigation, leakage from water/sewer lines, and direct infiltration of surface water runoff (infiltration ponds, dry wells, etc.). [Groundwater recharge due to infiltration of effluent beneath septic drain fields was assumed to be 87 percent of the water used by single-family residences. Other assumptions were made regarding recharge from these sources to support estimates of the total water budget \(page 5.2-17\).](#)

Groundwater Flow Direction

Regional information regarding groundwater flow direction and elevations is available for portions of the McAllister and Yelm subbasins and the Muck/Murray subbasin. Additional information is available locally for other portions of the basin (page 5.2-18 to 5.2-20), [however information is missing for much of the watershed.](#) The flow of groundwater is generally to the northwest and towards the mainstem. Variations in this flow pattern are discussed under the subbasin summaries.

WATER USE AND WATER RIGHTS

Water Right Permits and Applications

The water rights and water use section of the Level I Watershed Assessment addresses the amount of water allocated under the water rights awarded by the State of Washington and estimated actual water being used in each subbasin. Ecology is the state agency in charge of administering water rights. Ecology has developed a database, called Water Rights Allocation and Tracking System (WRATS), summarizing the water rights in each Water Resources Inventory Area (WRIA), which was used for the analysis. [The WRATS database has a number of errors in it, particularly with regard to locations of rights.](#) The locations of major water rights were corrected in the dataset used for this analysis. [The WRATS database has not been corrected. Errors no doubt also remain regarding mapping of smaller water rights \(page 5.3-3\).](#)

There are four different types of water rights discussed in the analysis: applications, permits, certificates, and claims (page 5.3-2). An *Application* is a request submitted to obtain a water right certificate from Ecology. A *Permit* is permission given to water right applicants by the state to develop a water right. Water right permits remain in effect until the water right certificate is issued, if all terms of the permit are met, or the permit has been canceled. A *Certificate* is issued by Ecology to certify that water users have the authority to use a specific amount of water under certain conditions. The water right certificate is a legal document recorded at the county auditor's office. A *Claim* is a statement of claim to a water use that began before the State Water Codes were adopted and is not covered by a permit or certificate. Water rights represent the major portion of the allocated water, however, ground water withdrawals from wells that are not required to have a water right (generally referred to as exempt wells) are also legal uses of water.

For the purposes of conducting the Level I analysis, several assumptions were made. These assumptions were the most reasonable assumptions that could be made where accurate information was missing. These assumptions are described in detail on pages 5.3-4 to 5.3-5 of the main report.

There are three power rights in the basin, all of which are surface water diversions that allow 802.50 cfs to be diverted. One of the three diversions has a limit on the total volume that can be diverted each year. These rights are non-consumptive (all water withdrawn is returned) and only effect flow in the bypass reaches, between the point of diversion and the point where flow is returned. The City of Centralia holds two of these surface water rights for 800 cfs in total; 80 cfs of this has a 58,000 acre-feet total allowable annual volume. There is an additional power right for 2.50 cfs under the name L.C. Fitch dated 1932.

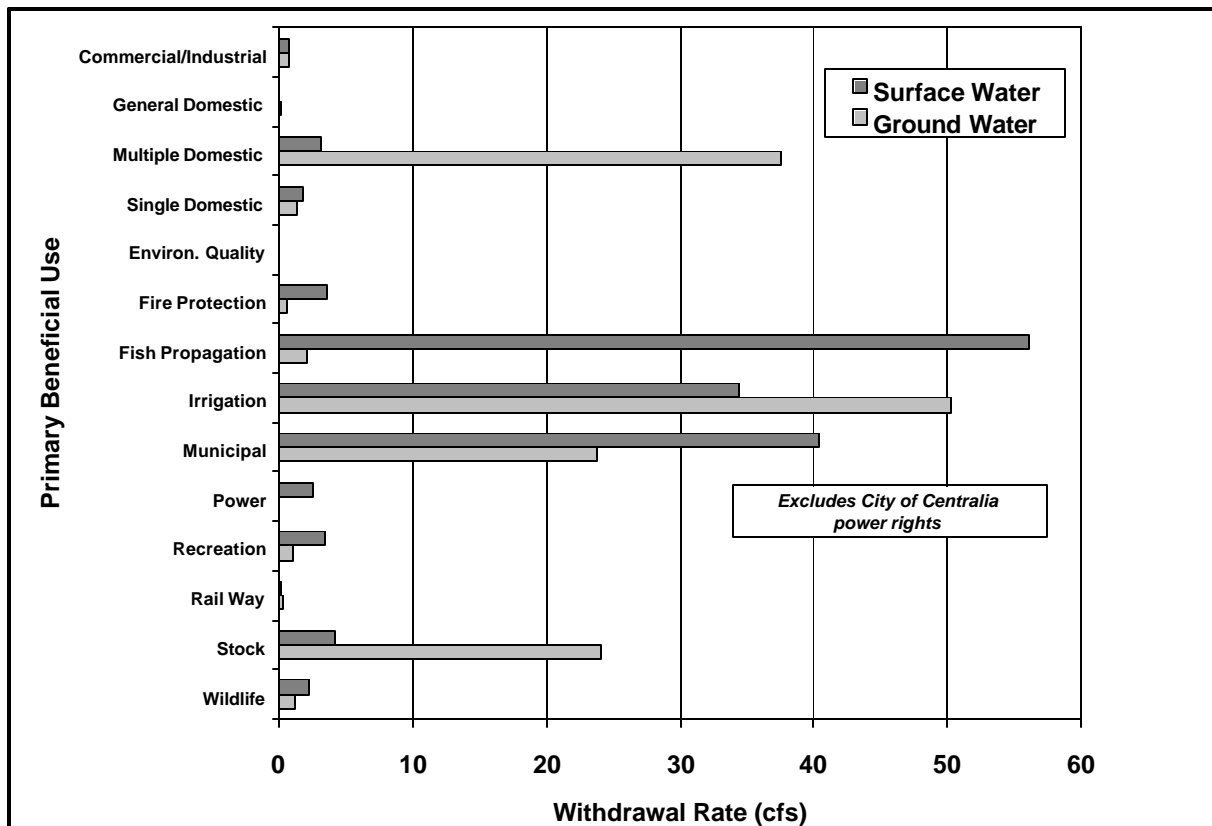


Figure 7. Summary of diversion/withdrawal allocation by primary beneficial use (cfs)

In the Lower Nisqually River Basin, there were a total of 938 certificates, permits, and applications and 2,677 claims (page 5.3-5). The total allocated amount of water for diversions/withdrawals was 1096.56 cfs with an annual volume limit of 63,078 acre-feet, excluding hydropower (additional 58,000 acre-feet). The total volume of storage rights was about 265 acre-feet. The water rights cover roughly 9,689 acres of irrigated land; 842 of these acres were listed under applications. In addition to the permitted rights,

numerous exempt wells in the watershed serve one to 6 houses. These are not reflected in the permits, rights, and applications.

Water rights and certificates are generally designated for specific uses. The majority of the consumptive water right allocations in the Lower Nisqually were designated for municipal, multiple domestic, and irrigation water use. Roughly half of the amount of water has been allocated for consumptive use comes from each, surface and groundwater sources (Figure 7, page 5.3-12). Of the three largest surface water rights, the City of Olympia holds two. The Washington Department of Fish and Wildlife holds the other for fish production (page 5.3-12). The largest groundwater rights were for irrigation. Water used by the City of Olympia and most of the water used by the City of Lacey is exported out of the Nisqually watershed.

Water Use

Typically, the amount of water actually used is less than the amount that has been allocated. *Actual water use has not been systematically recorded in the watershed except for large diversions and withdrawals for municipal or multiple domestic uses. Hence, estimates of actual residential and agricultural water use were developed.* Additionally, some portion of the water used is eventually returned to a stream or to groundwater storage areas. For example, some portion of the water used for irrigation typically runs off to a stream or percolates back into the groundwater. Likewise, some portion of the water that is treated in septic systems eventually makes its way back into the groundwater. The water that is used but eventually returned to streams or groundwater systems is known as return flow. *Return flow is seldom measured; hence, estimates of the quantity of return flow were also developed.*

Residential use was estimated using population estimates from the 2000 Census data and information provided by the water suppliers regarding average water use of residences by month (pages 5.3-16 to 5.3-22). Return flow was estimated for the portion of the water that is used within the subbasin. All of the water used by the City of Olympia and most of the water used by the City of Lacey is exported out of the watershed to serve customers in each city; hence, none of this water is returned to water bodies in the watershed.

There are an estimated 559 public water systems in the watershed. A total of 17,246 residential connections and 10,751 non-residential connections are included in the systems. The total population served by these systems is estimated at 44,032, or roughly 72 percent of the total population of 60,773 people in the watershed. The remaining 28 percent of the residential population is self-supplied, covered by domestic water rights or exempt wells (wells that legally are not required to have a water right).

For the year 2000 population, the average water demand for people residing within the watershed was estimated at about 14 cfs (9.1 million gallons per day) in winter and 28 cfs (18.2 million gallons per day) in summer (page 5.3-22, Figure 8). Once return flow is accounted for, the net depletion (water diverted minus water returned) is estimated at a

little more than 2 cfs in winter and 8 cfs in summer. These estimates do not include the water used by persons served outside of the watershed boundaries.

Estimates of future water demand were also calculated. The average demand estimates for the year 2020 population may be more than 20 cfs (12.9 million gallons per day) in winter with a 3.3 cfs net depletion to the ground and surface water sources (page 5.3-23). During the season of outdoor water use, usually from May through September, the demand could reach as much as 45 cfs (29.1 million gallons per day) with a net depletion of 13 cfs.

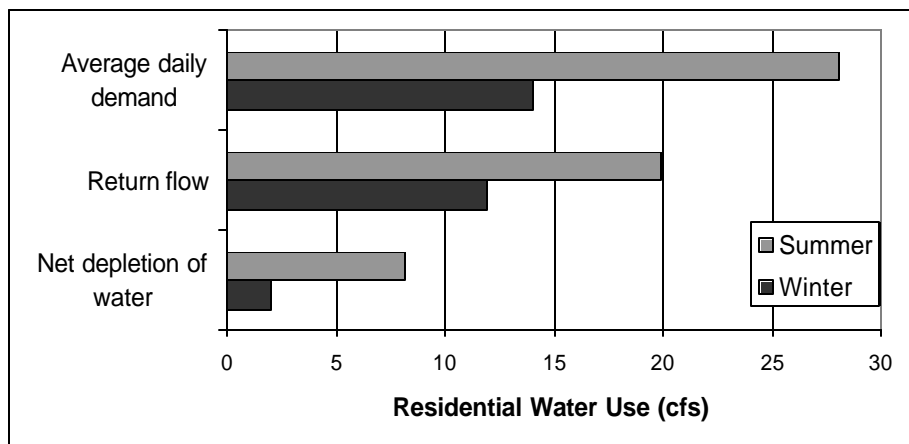


Figure 8. Estimated seasonal residential water use (cfs) for the year 2000 population.

Little or no information is available that details the spatial distribution of irrigated agriculture in the Lower Nisqually Basin. The USGS reported there were 1,270 acres of irrigated land in 1995 in WRIA 11. Approximately 1,180 acres are irrigated by a sprinkler method and 90 acres are irrigated by micro-irrigation (also known as trickle or drip irrigation) (page 5.3-32). USGS reported that 4.6 acre-feet of water are used per day from ground water sources and 2.6 acre-feet are used per day from surface water sources, for a total of 7.27 acre-feet (2.4 million gallons) per day. Given the 1995 USGS estimate of 1,270 irrigated acres, the actual volume of water used appears to be much less than the volume that has been allocated through water rights. Irrigation water rights cover 8,798 acres of land with an allocated annual volume of more than 16,400 acre-feet. Actual use appears to be on the order of 14% of the water righted acreage based on the 1995 USGS Water Use Data. Given the large difference in the allocated volume and the estimated actual use for irrigation purposes, further analysis is recommended to improve the accuracy of estimates of the actual water use.

Return flow from irrigation of crops has been estimated at 57% of the volume of water diverted for irrigation. Return flow from diversions for watering stock is estimated at 13% of the total volume of water diverted for that purpose.

Comparison of Streamflow and Allocated Water

For each subbasin, allocated water was compared to streamflow (page 5.3-39). Estimates of the net depletion (water withdrawn minus water returned) to streamflow were made for each major water use in the watershed. The values used for water withdrawals were the maximum legal withdrawals allowed under existing water rights. As was discussed in the previous section, actual use is lower than the total allowable use. The difference is particularly pronounced from agricultural use. Hence, these estimates of total potential depletion under existing water rights are greater than current depletions.

Total potential depletion of water from the Nisqually River (assuming 100% of the water volume allowed under existing rights is actually withdrawn) was estimated at 1.71 cfs in winter and 18.25 cfs in summer (page 5.3-40). These numbers do not include water withdrawn in the McAllister subbasin since McAllister Creek does not drain into the Nisqually River. Estimated depletions represent a very small portion (less than 3%) of the total flow in the Nisqually River (Figure 9).

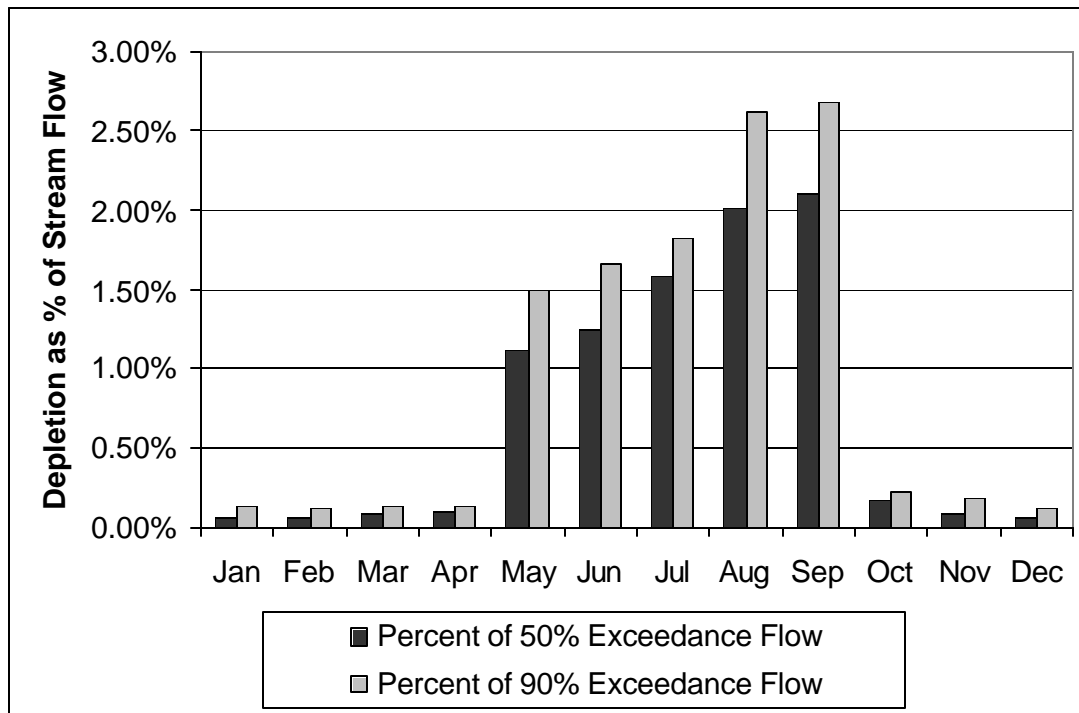


Figure 9. Percent of total Nisqually River flows that could potentially be depleted if all existing water rights were fully used. Depletions are estimated as total volume that could be withdrawn minus estimated return flow. 50% exceedance flow is roughly average flow. 90% exceedance flow is a low flow that is expected to occur in no more than 1 year in 10.

WATER QUALITY

Surface Water

Water quality in the Lower Nisqually Basin was evaluated using data sources from the Nisqually Indian Tribe and Ecology's ambient monitoring program. The Level I Assessment focused on dissolved oxygen levels, stream temperature, and fecal coliform bacteria (page 4-1). These parameters were selected for the assessment because of their direct relationship with fisheries and water quantity issues. Other violations of water quality standards were also documented.

Water quality standards have been set for surface waters of Washington State based on the beneficial uses of the water (page 4-2). The water quality standards for temperature, dissolved oxygen (DO), and fecal coliform levels in the Lower Nisqually basin are specified in Table 3. On a biennial basis, the EPA is required to create a list of "impaired" waterways in the U.S based on documented violations of water quality standards. Two segments in the Lower Nisqually Watershed have been placed on this list. These include McAllister Creek and the lower Nisqually River.

In terms of water quality standards, the mainstem appears to be in good condition (page 4-23). The minimum dissolved oxygen concentrations at all stations were well above the state standard, even during late summer. The stream temperature standard is occasionally exceeded at RM 3.7, but the maximum recorded temperature is only slightly higher than the standard. Fecal coliform levels are occasionally exceeded in winter at RM 3.7 and RM 21.8, near the McKenna Diversion. Levels at the lower station are slightly higher than the standard.

There are several areas in the subbasins where temperature, dissolved oxygen, and fecal coliform standards are violated. Many of the temperature and dissolved oxygen situations are thought to be entirely or largely natural in origin.

Table 3. Selected Washington State water quality criteria for Class A waters.

Class	Temperature	DO	Fecal Coliform
A	Shall not exceed 18°C from human conditions or if >18°C exists naturally, no temp increase >0.3°C	Shall exceed 8.0 mg/L	Shall not exceed a geometric mean of 100 colonies/100mL and shall not have > 10% of all samples exceeding 200 colonies/100mL

Agricultural activities (identified as agriculture, small farms, and dairy/cattle) are implicated as probable sources of water quality problems on McAllister Creek the lower reach of Yelm Creek, and in the lower Ohop valley (page 4-25). Forestry is implicated in Lynch Creek (Ohop) and the upper Mashel. Residential development is only implicated as a problem source in parts of the Ohop system. The specific situations are discussed below under the subbasin summaries.

Review of the data suggests three areas where temperature and dissolved oxygen levels are at (or are approaching) levels of critical concern for fish. These are Powell, upper Murray, and Ohop Creeks (particularly below the lake). In each of these cases, water quality is likely a reflection of the presence of lakes or wetlands above the sampling stations. The situations may therefore be natural. Lower Ohop Creek also has significant temperature and dissolved oxygen problems that are likely related to land use (page 4-25).

Groundwater

Groundwater quality was also evaluated in the Level I Assessment. The primary data used were provided in a U.S. Geological survey study and a WDOH database. In terms of meeting drinking water standards, groundwater quality appears to be good throughout most of the Nisqually Basin (page 4-38).

Nitrate concentrations have been measured by the Washington Department of Health in 374 wells in the basin. Only 12 of these samples exceeded drinking water standards and 6 of those measurements came from one well (351st Street Well Association). Evidence of elevated nitrates was found in many wells in the McAllister (50%) and Yelm (30%) subbasins, but the levels fell below the standards (page 4-33).

Chloride data was available for 227 wells. Another 54 measurements were also available from the USGS study. Chloride levels fell well below the drinking water standard of 250 mg/L in all samples (page 4-34).

[Data on fecal coliform levels in groundwater was more limited.](#) None of the 53 wells monitored in the McAllister and Yelm Creek subbasins exceeded the drinking water standard for fecal coliform (0 coliforms per 100 ml) (page 4-36).

FISH SPECIES AND FISH HABITAT

Fish species in the watershed include chinook, chum, coho, and pink salmon, steelhead, rainbow trout, cutthroat trout, and kokanee (sockeye salmon that do not go to sea, introduced into Alder Lake) (page 3-2). [Sockeye salmon have occasionally been seen in the basin, but are thought to be strays into the watershed or kokanee that have left the reservoir \(page 3-4\).](#) [Bull trout are thought to live in the basin, through very little information exists regarding their presence \(page 3-4\).](#) The Nisqually River fall chinook and the Nisqually bull trout have been listed under the Endangered Species Act as threatened (page 3-2). The Nisqually River coho salmon is a candidate for listing.

The largest quantities of habitat for salmon are found in the Mashel, Muck/Murray, and Tanwax/Kreger/Ohop subbasins, as well as in the mainstem of the river (page 3-5). Movement of salmon into many of the other subbasins is limited by natural or manmade barriers. Habitat quality varies widely throughout the watershed.

Numerous warm water species have been introduced into lowland lakes throughout the basin including largemouth bass, yellow perch, bluegill, pumpkinseed, and bullheads

(page 3-6). Little is known about their distribution and status, although populations appear to be small.

The mainstem of the Nisqually River provides migration habitat for all the salmonid species in the basin, spawning habitat for chum, coho, chinook and steelhead, and rearing habitat for most of the salmonids in the basin. The mainstem generally has good habitat. The abundance of instream wood may be sub-optimum in the upper and some of the middle reaches.

DATA GAPS AND RECOMMENDATIONS

Five major data gaps were identified and recommended for considerations for further study (page 7-1). These included:

- **Estimation of natural stream flows (page 7-1).** As was indicated earlier, stream flow measurements reflect current use and not natural stream flows. To better understand the impact of water rights allocations, the current use would need to be estimated and added back into gage flows to get a more accurate picture of natural flows. Then a comparison of these estimated natural flows and the water rights allocation could be achieved.
- **Improve estimates of actual irrigation water use (page 7-2).** The initial assessment suggests that actual irrigation water use may be substantially lower than the water allocated for such use. Improved estimates of actual irrigation use would provide a better understanding of the overall water budget.
- **Groundwater Modeling (page 7-3).** A new modeling effort is underway that covers a large area, including McAllister Creek. This model will be used for evaluating impacts from allocations from McAllister Creek. When this is complete, the results of this effort should be reviewed and this initial assessment updated as appropriate. Opportunities may exist to use the new model or the older models to learn more about groundwater/surface water interactions, improve upon understandings of the groundwater situations in Yelm and Muck/Murray subbasins, and evaluate potential management options.
- **Stream gages (page 7-4).** Stream gage records for some of the subbasins cover a relatively short time period. These short records were extrapolated to estimate patterns of instream flow. Uncertainty introduced through these extrapolations is most pronounced for streams in the lower basin. Estimates of water available would be improved if additional stream gage data collected over a longer period were available. Options for collecting data are detailed in the main report.
- **Instream flows (page 7-7).** The instream flows set in the mainstem were based on robust data. Instream flows and closures in the subbasins are based on minimal data. A closer review of the methods used to develop these instream flows is recommended. Instream flow studies may be merited in subbasins with an abundance of fish habitat or significant future water demand.

Numerous other data gaps were identified (pages 7-7 through 7-14) and recommendations made for addressing those gaps. These recommendations included improvement of databases, to data collection, and additional analyses.

MCALLISTER SUBBASIN

The McAllister subbasin is located at the western-most end of the watershed and drains primarily to Puget Sound. McAllister Creek, which is roughly 6 miles long, is the primary tributary in the watershed and originates from groundwater springs. McAllister Creek also receives flow from a number of smaller springs located along the west border of the lower Nisqually valley and receives flow from Medicine Creek and Little McAllister Creek. In addition to McAllister Creek itself, the subbasin also includes several small streams that drain to the mainstem Nisqually or directly to Puget Sound. Numerous small to moderate size lakes are present in the watershed, including Lake St. Clair.

A number of springs comprise the headwaters of McAllister Creek. The largest have been developed by the City of Olympia to provide urban water supply. A salt wedge extends up McAllister Creek nearly to the headwaters and tides influence flow to RM 5.5 (the uppermost portion of the creek). Stream channels are generally low gradient.

LAND USE

Land use in the McAllister subbasin is diverse (Figure 10). The lower portion of the subbasin is primarily rural residential and the upper part of the subbasin is primarily forested. The Nisqually National Wildlife Refuge lies near the mouth of McAllister Creek. Other land uses include agriculture, residential, commercial, industrial, and park/open space (page 2-24).

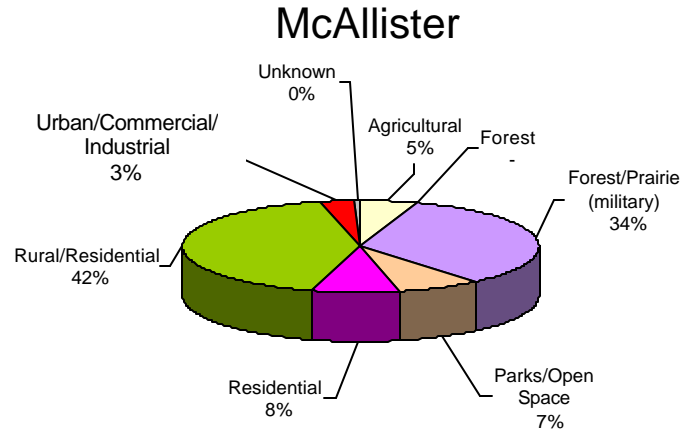


Figure 10. Land use in the McAllister Creek subbasin (Page 2-30).

FISH AND FISH HABITAT

McAllister Creek supports populations of coho, winter steelhead, chinook, and possibly a few pink salmon (page 3-7). Spawning is very limited in the stream (page 3-7). The lower reaches do not support spawning due to the presence of peat and fine sediment as well as the presence of the salt wedge. Spawning is limited to a very small area in the upper reach. A WDFW Fish Hatchery, which produces chinook salmon, is present near

the Steilacoom road crossing. Disease and parasite problems prevent the hatchery from operating at full capacity.

Other streams in the subbasin do not connect directly to McAllister or the Mainstem but rather serve as inflow to lake systems. There are impassable road-crossing barriers on Eaton Creek at Yelm Highway and Evergreen Valley Road that prevent adult upstream passage (page 3-7). Habitat impacts include dikes and armoring at road crossings that limit channel migration and off channel rearing habitat.

McAllister Creek and its tributaries, except Medicine Creek, have been closed year round to further allocations by Ecology. This closure was set to protect instream flow needs for fish (page 3-21). [The closure was not based on studies relating fish habitat to stream flow, hence review of this closure may be in order \(page 3-26\).](#)

PHYSICAL PROPERTIES

The McAllister subbasin is a low elevation, relatively flat subbasin. It has a mean elevation of 244 feet above sea level (page 2-3). Elevations range from 0 to 640 feet.

The geology underlying the McAllister subbasin is dominated by unconsolidated materials, including glacial deposits, glacial outwash, and alluvium (recent river deposits) (page 2-10). Groundwater passes easily through most of these deposits, although local accumulations of finer sediments may act as barriers to the movement of water.

Soils in the subbasin are highly variable. Approximately 39% of the soils are considered highly permeable, 18% are moderately permeable, 30% have slow infiltration rates, and 12% have very slow infiltration rates (page 2-7). Precipitation in the subbasin averages around 33 to 45 inches per year (page 2-15).

STREAM FLOW

The McAllister Springs gage (#12081500) was used to represent stream flow conditions in the McAllister subbasin (page 5.1-5). The gage is located at the upstream end of the creek, approximately 5.5 miles upstream from the outlet of the subbasin. [Stream flow data collected at this site was collected only in years that were wetter than average, consequently, calculated streamflow statistics might overestimate average conditions.](#) Flows at the McAllister Springs gage are highly regulated by the City of Olympia's water withdrawals. No major dam storage occurs in the subbasin (page 5.1-6).

The USGS has not defined a drainage area contributing to the McAllister Creek gage due to the complex geology and groundwater dynamics in the area (page 5.1-10). [Consequently, it is not possible to define a unit-area runoff for the gage record.](#) Using an estimate of the ratio of stream flow at the mouth to that at the springs, an estimate of the annual contribution of various tributaries was developed (page 5.1-10). [Due to the uncertain nature of the unit-area runoff, these estimates may not be representative of the true situation.](#)

Flows in McAllister Creek tend to be relatively constant throughout the year, reflecting the influence of the large springs at its headwaters. Average monthly flows (50% exceedance flows) range from 54 to 72 cfs (Figure 11, page 5-11). These flows do not include water diverted at the headwaters by the City of Olympia.

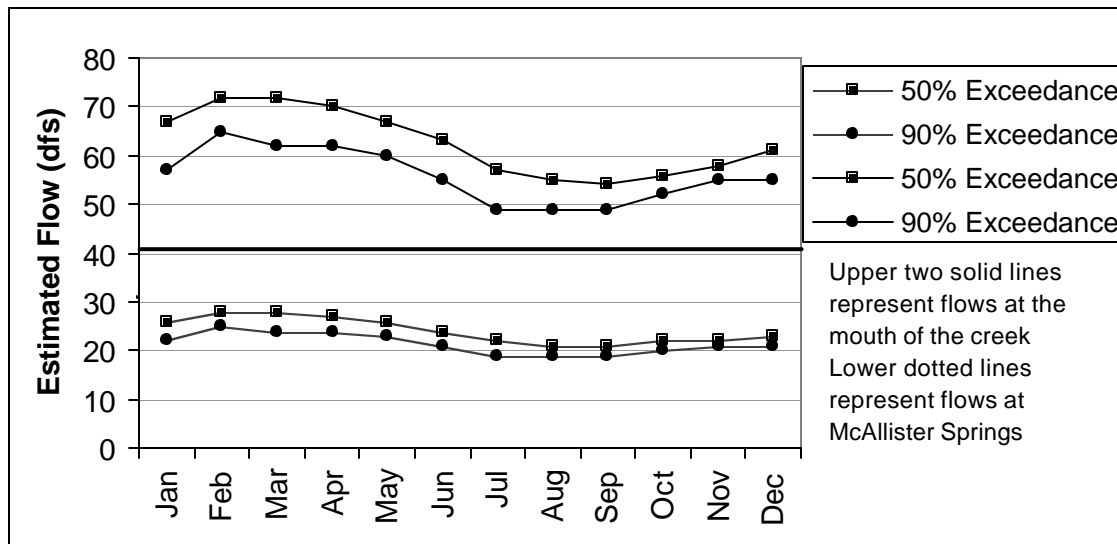


Figure 11. Estimated Flow Exceedance Values for McAllister Creek

GROUNDWATER RESOURCES

The McAllister subbasin has more information regarding groundwater resources than the other subbasins. [Previous groundwater models have been developed that include the McAllister area, however, these models, incorporate a number of simplifying assumptions that likely do not accurately reflect the true nature of the groundwater situation \(page 5.2-2\).](#) Presently, a new model is under development. [When complete, this model should be reviewed and the results of the Level I analysis should be updated as appropriate. The summary provided below is based on the earlier model as well as additional simplistic analyses.](#)

The majority of the McAllister subbasin overlies glacial deposits and outwash (page 5.2-3). The unit generally consists of well-sorted sand and gravel. These sediments, and the aquifers within them, likely extend beneath portions of the watersheds to the north and south of the Nisqually basin (page 5.2-12). Therefore, it is highly likely that some exchange occurs with adjacent basins. It is also likely that several aquifers in the area are in direct hydraulic continuity with each other, particularly near McAllister and Abbot Springs (page 5.2-22). Groundwater flow in two of the more productive geohydrologic units tends to converge in the area of McAllister Springs and McAllister Creek in the northern portion of the subbasin (page 5.2-20).

Annual groundwater recharge through precipitation is estimated at 26.6 to 29.3 inches per year (page 5.2-15). Data presented by the USGS suggests that Lake St. Clair provides a significant amount of recharge to groundwater in the McAllister basin. Water balance calculations for the area indicate a net flow to the groundwater system of 4,000 acre-feet per year (page 5.2-16). Other lakes and wetlands may also provide substantial recharge.

The water balance and water use analysis indicate that the net depletion to water resources in the subbasin due to the currently allocated water rights comprises roughly 80 to 90 percent of the estimated groundwater recharge in the basin (page 5.2-44). Based on the simplistic analysis that was conducted, it would appear that the potential influence of water use on streamflow is “high” at the watershed scale in the McAllister subbasin. However, it is likely that a large volume of the water derived from the subbasin originates outside the subbasin as groundwater through flow (page 5.2-45). Through flow of groundwater under this watershed has not been estimated in this analysis. Therefore, the overall impact of water use on streamflow in the subbasin is likely significantly less than the 80 to 90 percent suggested by the initial analysis. Additional analysis of the groundwater flow system is necessary to quantify the impact of groundwater through flow on streamflow and water use. The AGI/CDM model currently under development may provide better information for evaluating overall the water budget in the subbasin.

WATER USE AND WATER RIGHTS

Water Rights Certificates, Permits, Applications, and Claims

The water rights for fisheries production allow for the highest diversion rates in the McAllister subbasin (Figure 12). Three rights for fish production allow the diversion of 47 cfs. These are non-consumptive rights. Water is returned to the stream and hence these rights do not cause any reduction in streamflow (page 5.3-48).

McAllister subbasin also provides the source of water for 17 municipal water right certificates and permits. The 31,231 acre-feet annual volume allocated to municipal rights far exceeds the annual consumptive volume of any other use (Figure 12). The majority of the water withdrawn under these rights is exported out of the Nisqually watershed.

The City of Olympia has three certificates, one permit, and one application in the water rights database (page 5.3-42). Total volume permitted under the certificates and permit is 26.1 million gallons per day. The limit on the total volume of water withdrawn annually is approximately 29,168 acre-feet. An application for water rights has been submitted to WDOE to withdraw water from groundwater wells rather than the current point of withdrawal from McAllister Springs. To date, this application has not been issued.

The City of Lacey has 14 different water rights for their water sources within the McAllister Subbasin (page 5.3-42). The total annual volume of these rights is 2,033.8 acre-feet. The City of Lacey also has applications pending for four ground water rights totaling 8,450 gpm.

The McAllister subbasin also provides the source of water for 38 multiple domestic water right certificates and permits. The multiple domestic rights are entitled to use a combined 1,183 acre-feet per year.

The irrigation water right certificates in the subbasin cover 2,383 acres (page 5.3-44). [The extent to which these are actually being irrigated is unknown.](#)

Overall, the water rights in the McAllister subbasin represent, by volume, 62% of all the consumptive water allocated in the Lower Nisqually Basin (page 5.3-41).

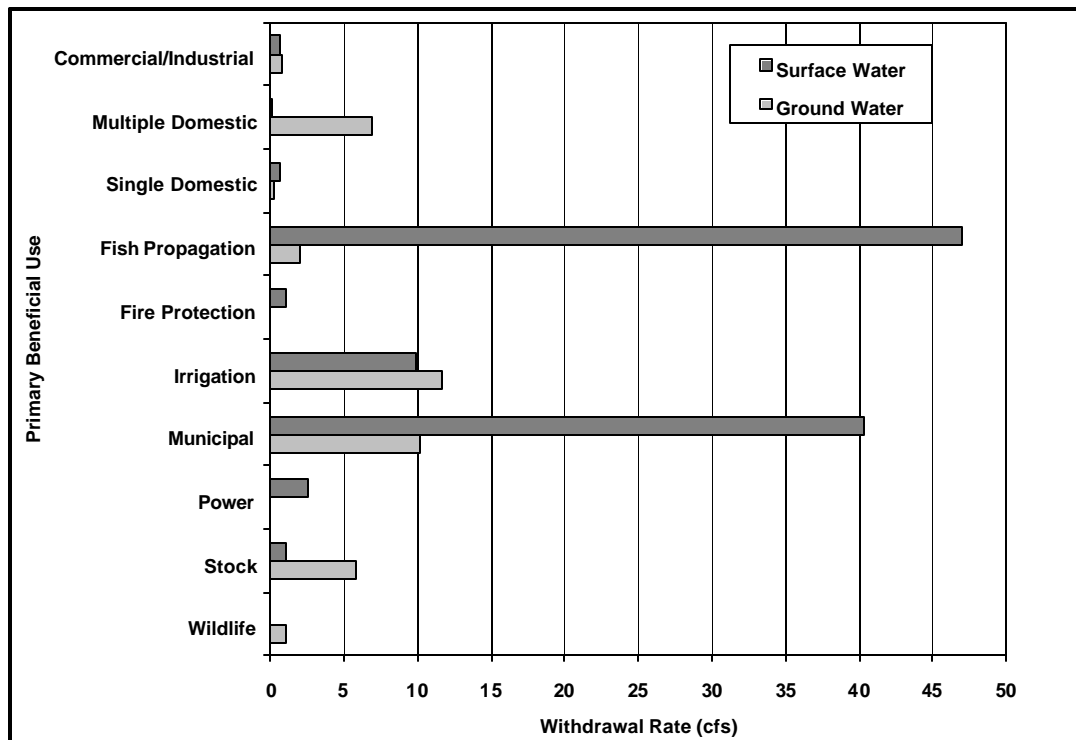


Figure 12. Allocated diversion/withdrawal rates (cfs) by primary beneficial use in McAllister subbasin.

Water Use

The following analysis describes a quantitative view of water use, which is based only on annual precipitation, and recharge values for the surface water capture area for the McAllister subbasin. Ongoing investigations by the City of Lacey and the City of Olympia indicate the actual groundwater availability in the subbasin far exceeds the amounts portrayed in this analysis.

The McAllister population from the 2000 census was estimated at 13,590 (page 5.3-49). The subbasin is the source of water supply for 63 public water systems serving 12,030 people (page 5.3-50). An estimated 1,560 people are self-supplied under either a multiple

domestic right or an exempt well. [Some of the multiple domestic rights may be associated with a public water system.](#)

Based on the estimated average day demand of 148 gallons per capita per day (gcd) and the maximum day demand of 296 gcd, the winter season residential demand for this subbasin was approximately 3.1 cfs (2 million gallons per day) and the summer season demand was 6.2 cfs (4 million gallons per day). The maximum net reduction in stream flow from residential water use by the population in the subbasin was estimated at 0.82 cfs and 1.64 cfs, respectively. This accounts for the in-basin water use and the out-of-basin sewage exports by City of Lacey customers. Out of basin transfers of water supply additional demand outside of the watershed. These out of basin transfers include the surface water rights for municipal use held by the City of Olympia and the majority of the water rights held by the City of Lacey. These out of basin transfers constitute 100% depletion to the system (page 5.3-48).

Comparison of Streamflow and Allocated Water

There is a great deal of uncertainty regarding the actual volume of water available in the McAllister subbasin. [As was indicated earlier, recharge to the groundwater system and continuity between aquifers and other watersheds may be high. The volume of groundwater through flow under the subbasin has not yet been estimated, however, preliminary results of ongoing studies suggest that large volumes of water may be present. Analyses of available water relative to consumption should be updated when improved information regarding groundwater resources becomes available.](#)

WATER QUALITY

McAllister Creek is included on EPA's 303(d) list due to both dissolved oxygen and fecal coliform problems (page 4-6). Other water quality parameters are reasonably good. Ecology has listed the assessment of the water quality situation and development a plan to address water quality problems as a priority for fiscal year 2002. This plan is referred to as a TMDL.

At river mile 3.1 (measured upstream from the mouth of the creek), the fecal bacteria standard is exceeded 11% of the time in summer and 18% of the time in winter (page 4-5). A significant correlation was found between fecal coliform concentrations measured in McAllister Creek and those measured over the shellfish beds located in Nisqually Reach (page 4-27). Typically, elevated fecal coliform levels are the result of runoff of animal waste and/or leaky septic tanks. At the same location, the dissolved oxygen standard was exceeded in 44% of the samples taken in summer and 22% of the samples taken in winter (page 4-5). Low dissolved oxygen levels are likely influenced by groundwater sources (which are naturally low in dissolved oxygen), the presence of peat, which uses available dissolved oxygen as it decays, and the decay of fertilizers and organic material that has runoff from adjacent lands.

Near the headwaters at river mile 6.3, the dissolved oxygen standard was exceeded in 57% of the samples in both summer and winter. The measurements at the upper end of

the stream likely reflect the dominance of groundwater inputs from the springs. Hence, the low dissolved oxygen levels are likely natural (page 4-4).

The quality of groundwater has been well studied in the McAllister subbasin. Nitrates measured in water from wells met the state standards in 99% of the samples collected (page 4-32). Half of the measurements that exceeded the standard were taken from one location (351st Street Well Association). Thurston County has identified two areas of concern in the McAllister subbasin where nitrates are elevated (though meet the standard). These locations include one site encompassing the north end of Long Lake, extending north of the lake, and one site southeast of the Long Lake complex. Chloride levels are within state standards (page 4-35).

DATA GAPS AND LEVEL II RECOMMENDATIONS

Top priority recommendations include (pages 7-1 through 7-14):

- Review the AGI/CDM groundwater model when completed and update the subbasin assessment as appropriate.
- Complete an assessment of the relationship between flow and habitat in the creek, accounting for tidal influence in the stream. Using this information and updated information on groundwater resources, evaluate the instream needs of aquatic resources to determine if further allocations can be supported.
- Include enterococci bacteria in future water quality monitoring to allow evaluation against the new water quality criteria.

MUCK/MURRAY

The Muck/Murray subbasin covers an area of 181.5 square miles in southeastern Pierce County (page 1-3). There are five major tributaries in the subbasin: Red salmon, Clear Creek, Muck Creek, Murray Creek, and Horn Creek (page 3-11). There are a few short spring-fed tributary streams in the lower reaches of the creek, most notably Exeter Springs, which is located at RM 2.5. These groundwater sources provide the majority of the yearly flow in lower Muck Creek (page 4-7). Both Murray and Muck Creeks become intermittent above river mile 0.6 (page 3-11). At times, flow in the lower reaches is also supplemented by discharge from a series of lakes and wetlands present between river mile 6.3 and 8.8. The largest of these lakes, Chambers Lake, is maintained by a small dam. In addition to the Chambers Lake dam, there are 5 other small dams present in the subbasin (page 2-27).

LAND USE

Land use is approximately 39% open forest and parkland, 7% agriculture, and 50% low density residential (Figure 13, page 2-24). Residential development is rapidly increasing with this subbasin. Ft. Lewis federal reservation encompasses a large portion of the

subbasin, however, there is no residential population on the reservation within the subbasin.

FISH AND FISH HABITAT

Despite intermittent summer flows, Muck Creek is the most significant tributary to the lower Nisqually. This system has seven major tributaries, containing 50 miles of habitat that support runs of chum, winter steelhead, and sea run cutthroat (page 3-11). The other tributaries contain small amounts of habitat for chinook, coho, chum, steelhead, chum, and sea-run cutthroat. Most of these streams have barriers to upstream migration within 1 mile of the mouth. Although little habitat is available for migratory fish, the small amounts of habitat in the lower reaches may provide important refuge for mainstem fish during high flow periods and the portions of the stream above the migration barriers may support trout.

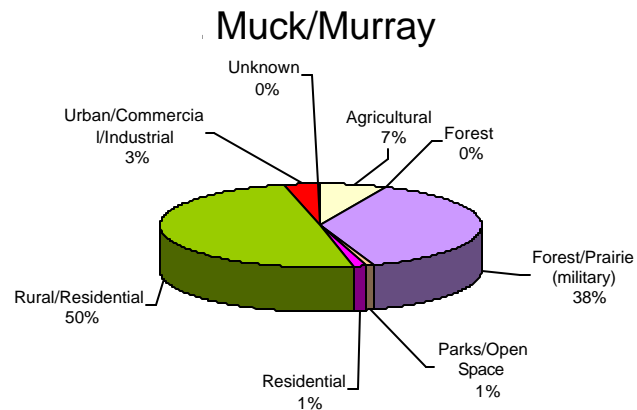


Figure 13. Land Use in the Muck/Murray Subbasin

Habitat in Muck Creek is generally good, although invasive reed canary grass has been identified as a problem in some areas (page 3-11). Habitat in Red Salmon Creek is considered fair to good overall, however wood in the stream may be low in places, and side channel habitat is considered poor. [There is limited data on habitat conditions in the other tributaries in the subbasin.](#) High sediment loads, low pool abundance, and low instream wood have been indicated in some areas of these streams.

Red Salmon Creek drains directly into the estuary and supports runs of coho, chum, steelhead, and sea-run cutthroat (page 3-11). A Salmon Hatchery for chinook and coho is present near the mouth of the Clear Creek.

Muck, Murray, Red Salmon, Horn, and Clear Creeks all have seasonal or year round closures to further appropriation (pages 3-21 and 3-22). [The information used to support these closures is unknown.](#)

PHYSICAL PROPERTIES

The Muck/Murray subbasin is one of the flattest subbasins in the WRIA. Mean elevation is 446 feet above sea level, ranging from 0 to 928 feet. Precipitation in the subbasin averages around 33 to 45 inches per year (page 2-15).

Geology underlying the Muck/Murray subbasin is dominated by glacial till and Vashon advance outwash (page 2-9, 5.2-11). Permeability of the glacial outwash deposits tends to be moderate to high.

There is no digital information regarding soils available for the subbasin. It is reasonable to assume that soil properties are similar to those in the Yelm subbasin, which include 19% soils with high infiltration rates, 20% with moderate infiltration rates, 31% with slow infiltration rates, and 30% with very slow infiltration rates (page 2-7).

STREAMFLOW

The Muck Creek at Roy gage (#12090200) was used to represent streamflow conditions in the Muck/Murray subbasin (page 5.1-6). The gage is located near the town of Roy, approximately 6 miles upstream from the outlet of Muck Creek. The portion of Muck Creek downstream of the gage cuts through the glacial deposits located within the area, and picks up considerable spring flow. Consequently, this gage may not adequately represent conditions in the lower portions of Muck Creek. All the data collected at this gage was collected during a period of above average precipitation. Consequently, streamflow statistics calculated using this data from this gage might overestimate average conditions.

Estimates of the 50% and 90% exceedance flows at the subbasin “outlet” were developed (page 5-12, Figure 15). The flows represented in these estimates include the combined flows of Muck Creek, Murray Creek, and the other smaller creeks in the subbasin. Flows in the Muck/Murray subbasin drop to near zero in summer and peak in January and February. Average monthly flows (50% exceedance flows) range from 34 to 389 cfs (Figure 13, page 5.1-13).

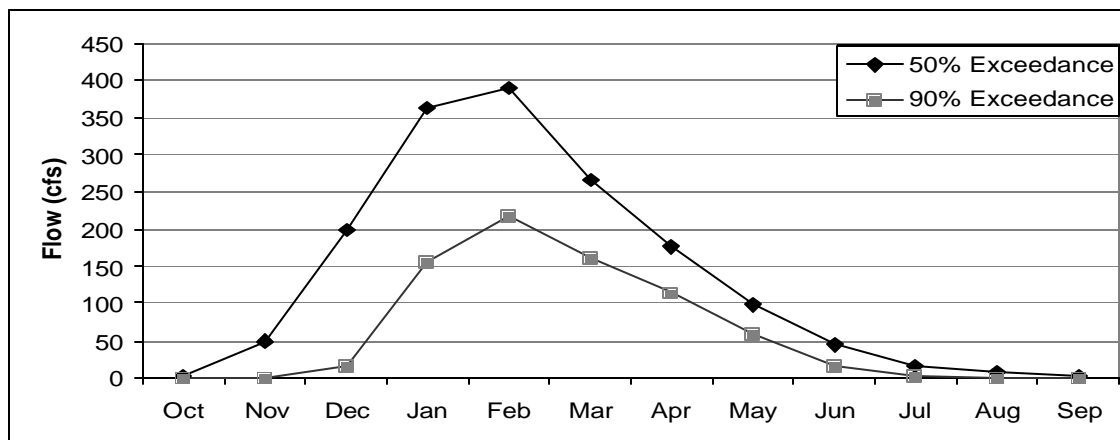


Figure 14. Estimated 50% and 90% exceedance flows for the Muck/Murray subbasin. The 50% exceedance flows represents the “average” flows in the subbasin. The 90% exceedance flows represent the flows in relatively dry years – flows are higher than this value in 90% of the years represented by the data.

GROUNDWATER RESOURCES

Information regarding groundwater resources was compiled from data presented in various USGS and private consulting reports and water purveyor information. This information includes summaries of the results of the USGS model that was discussed earlier. [Note, this model incorporated a number of simplifying assumptions that may not accurately reflect the true nature of the groundwater situation in the subbasin.](#)

One of the water bearing hydrogeologic unit underlying the Muck/Murray subbasin is the unit coded Qc (page 5.2-10). This unit is extensively used as a source of groundwater. Groundwater tends to be confined in this unit. The subbasin is also generally underlain by a substantial thickness of sediments deposited by glaciers that contain several aquifers. [These sediments and their aquifers may extend into adjacent watersheds \(page 5.2-12\).](#)

Annual groundwater recharge through precipitation is estimated as 21.5 to 23.7 inches per year (page 5.2-15). Lakes, streams, and wetlands may provide for substantial additional recharge in the subbasin. [Ecology is currently studying groundwater/surface water hydraulic continuity in the Muck/Murray subbasin. The results of this study may provide additional information regarding potential recharge from surface water to groundwater in the subbasin.](#)

Groundwater elevations in the aquifers range from over 600 feet above sea level in the eastern portion of Muck/Murray subbasin to generally less than 75 feet above sea level near Puget Sound (Page 5.2-18). Static water elevations at the eastern boundary of the subbasin range from approximately 625 to 540 feet above sea level.

A generally southwest to northeast trending groundwater divide is likely located on Graham Hill (page 5.2-19). Groundwater north of that divide likely flows into the Muck/Murray Creek drainage and potentially into the Clover Creek drainage. Groundwater flow south of the divide likely flows to the South Creek drainage, which is tributary to Muck/Murray Creek.

Components of a water balance were estimated monthly (page 5.2-37 to 5.2-41). The Muck/Murray subbasin receives approximately 42 inches of precipitation annually with roughly 51 to 56% ending up as groundwater recharge (page 5.2-45). Allocated water rights in the subbasin have been estimated at approximately 2 inches per year. Therefore, current allocated surface/groundwater rights could comprise approximately 8 to 9 percent of the estimated groundwater recharge in the Muck/Murray subbasin. There may, however, be considerable flow of groundwater under the lower portion of the subbasin. [The volume of this flow has not been quantified. Hence, much larger volumes of groundwater may be available than is suggested by the information currently available.](#)

WATER USE AND WATER RIGHTS

Water Right Permits, Certificates, and Applications

There were 70 surface water certificates and permits for a total diversion rate of 21.65 cfs (14 million gallons per day) and 217 groundwater rights for a total withdrawal rate of 24,351 gpm (54.2 cfs or 35 million gallons per day) in the Muck/Murray subbasin (page 5.3-56). Applications on are on file for an additional 0.7 cfs surface water rights and 12.1 cfs in groundwater rights.

The City of Dupont holds the largest right in the subbasin (page 5.3-56). This is a groundwater right for 2,200 gpm (4.9 cfs) with an annual volume limit of 774 acre-feet. Most of the city is outside of the WRIA; hence, most of the water represents 100% depletion to the subbasin resources. There is some question as to whether this right is actually located in the subbasin. The right was not included in calculations of water depletion. The next largest right is a non-consumptive right for fisheries production (page 5.3-56).

Multiple domestic rights and irrigation rights account for most of the annual allocated volume of groundwater. Groundwater allocations account for the majority of the rights in the subbasin (page 5.3-59; Figure 15).

Water Use

The population of the Muck/Murray subbasin was estimated at 27,454 people in the year 2000. The Muck/Murray subbasin is the source of water supply for 344 public water systems serving 20,355 people (page 5.3-62). In addition, there are 121 non-residential connections. There are an estimated 7,034 people that are self-supplied under either a multiple domestic right or an exempt well (page 5.3-63). [Some of the multiple domestic rights may be associated with a public water system.](#)

Based on the estimated average day demand of 153 gallons per capita per day (gcd) and the maximum day demand of 306 gcd, the winter season residential water demand for this subbasin was approximately 6.5 cfs (4.2 million gallons per day) and the summer season demand was 13 cfs (8.4 million gallons per day, page 5.3-62). Once return flow has been accounted for, the net depletion of water in the subbasin from winter and summer residential water use was estimated at 0.84 cfs and 3.64 cfs, respectively.

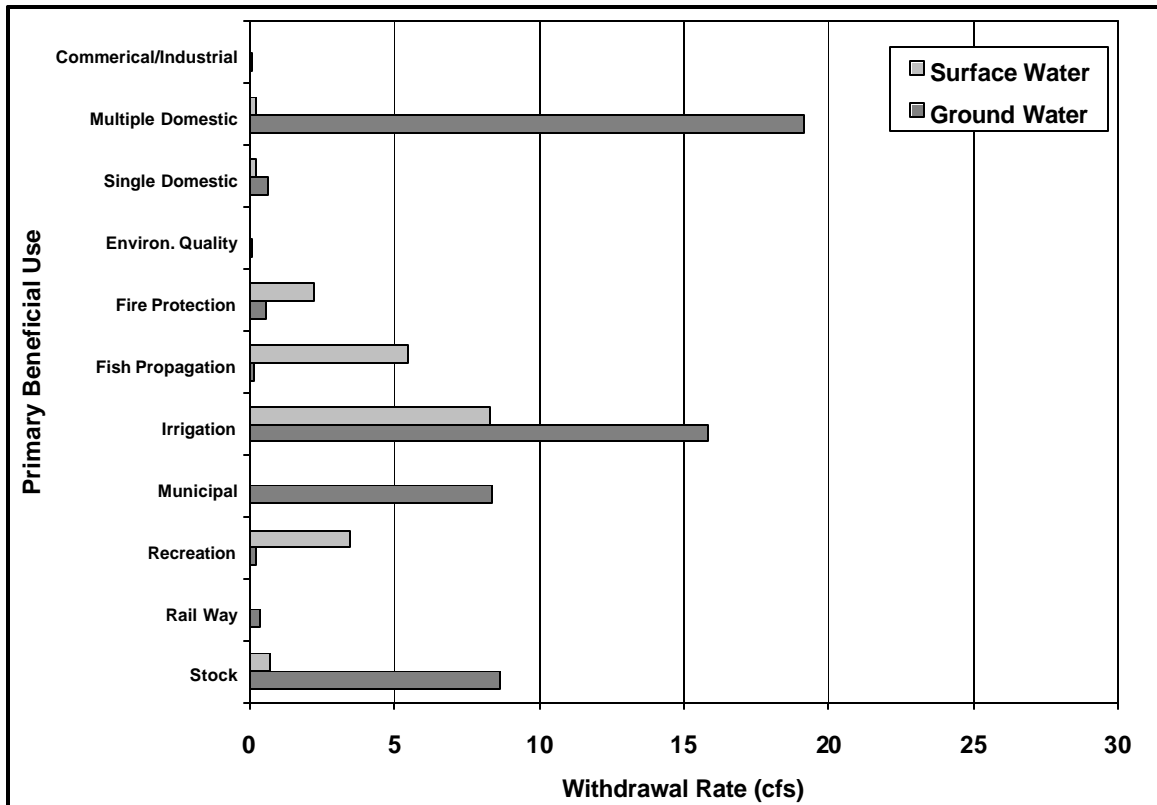


Figure 15. Allocated diversion/withdrawal rates (cfs) by primary beneficial use in the Muck/Murray subbasin.

Comparison of Streamflow and Allocated Water

Allocated water exceeds or very nearly exceeds streamflow at both the 50% and 90% values from July through October (page 5.3-66, Figure 15). The apparent over allocation in this basin is in part due to the low to nonexistent summer flows primarily at the 90% exceedance level. [Streamflow used in this level 1 analysis were not adjusted to account for upstream diversions; hence, that actual volume of water available is likely under-represented. The apparent situation is further overstated since groundwater rights were also included in this calculation and are assumed to be directly connected to surface water flows. More detailed investigation of the extent of surface water capture from groundwater pumping and improved estimates of natural streamflow are warranted for this basin.](#)

WATER QUALITY

There are two water quality monitoring stations on Muck Creek, both of which are within the lower basin (page 4-7). Water quality is generally good at the lower station, with the exception of the fecal coliform standard, which is exceeded roughly 7% of the time in winter (page 4-8). Dissolved oxygen, summer stream temperature, and fecal coliform

levels often fail to meet state standards at the upper station (page 4-8). Dissolved oxygen levels are low, but not low enough to typically cause mortality in fish. Temperature, on the other hand, has been recorded within the lethal range for fish. The situation with temperature and dissolved oxygen may reflect naturally warm temperatures and low dissolved oxygen levels of the wetlands near the station (page 4-9). The high fecal coliform levels are reportedly related to the agricultural land use in this part of the basin (page 4-9). [Information on the quality of groundwater was not available.](#)

Murray Creek also has two water quality monitoring stations (page 4-9). [No fecal coliform bacteria data were available for those stations.](#) Dissolved oxygen levels in Murray Creek are often below the state standard at both stations in summer and at the upper station in winter (page 4-8). The temperature standard is occasionally exceeded at the lower station. [Information on the quality of groundwater was not available.](#)

DATA GAPS AND LEVEL II RECOMMENDATIONS

The primary data gaps and recommendations for the Muck/Murray subbasin include (pages 7-1 to 7-14):

- [Review the AGI/CDM groundwater model once complete. Update groundwater assessment as appropriate. Explore the potential to use the available models to provide a more detailed quantitative spatial analysis of groundwater in the subbasin and the effects of groundwater withdrawals on stream flow. Areas of concentrated groundwater use such as the Towns of McKenna and Roy, and the Graham Hill area are recommended as focus areas for additional groundwater analysis.](#)
- [Improve estimates of natural stream flow and actual water use for irrigation.](#)
- [Re-establish the stream gage at Roy, install an additional gage near the mouth of Muck Creek, and establish a temporary gage near the mouth of Murray Creek, upstream of the reaches with high inputs of flow from springs.](#)
- [Muck Creek has significant quantities of fish habitat as well as high water demand. Conduct an instream flow study in Muck Creek to evaluate the quantity of water needed to protect fish resources in the subbasin.](#)
- [Expand water quality monitoring to include fecal coliform in Murray Creek and expanded monitoring of groundwater quality. Also, include enterococci bacteria as a monitoring parameter.](#)
- [Collect improved data on the fish habitat quality in Murray Creek and Red Salmon Creek.](#)

YELM

The Yelm subbasin drains 52 square miles of prairie around the City of Yelm (page 1-3). The average annual discharge of the creek is 40 cfs. Yelm Creek contributes approximately 2% to the annual flow to the Nisqually River (page 4-10). The headwaters arise from wetlands and springs that have developed in the depressions of the deep, poorly drained soils. The lower portion lies on permeable glacial outwash terraces, where numerous springs provide the majority of the yearly flow. Yelm Creek is intermittent above river mile 1.4 as measured from the mouth of the creek).

LAND USE

Land use in the Yelm Creek subbasin is primarily rural residential (Figure 16, page 2-24). Other land uses include agriculture, forest/prairie, urban/commercial/industrial, and residential. The City of Yelm is the major metropolitan area within the subbasin. The Yelm Hydroelectric project was constructed in 1929. Another small dam was completed in 1991 to support the Winsor water ski pond (page 2-27).

FISH AND FISH HABITAT

Yelm Creek supports populations of chum, winter steelhead and sea run cutthroat (page 3-14). Coho and chinook have also been observed in the lower reaches. Because the stream maintains stable surface flow in early summer, it is an important rearing and/or high flow refuge. However, flows become intermittent in the summer above river mile 1.4 and there is a natural barrier at river mile 0.4 (Page 3-14). There is limited habitat information available in the upper creek. Unverified concerns about sediment in the stream have been documented. Habitat in and around the City of Yelm is degraded. Invasive species abound in the riparian areas and in the stream. Sediment loads are high and the abundance of wood is low.

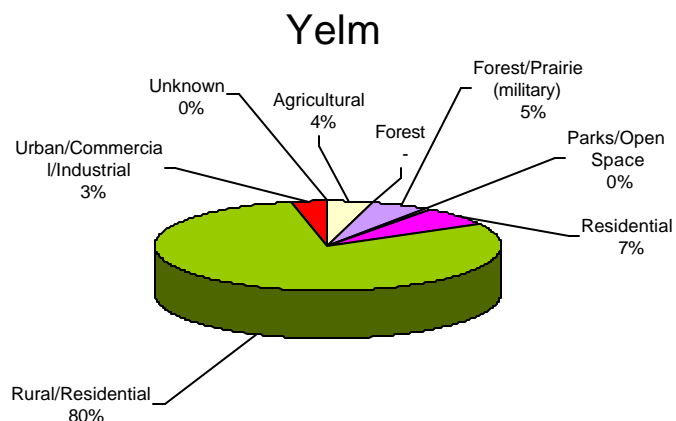


Figure 16. Land Use in the Yelm Subbasin

Kalama Creek is a 1.5 miles long stream that is also located in the subbasin. There is a chinook and coho hatchery located on the creek that limits upstream movement of fish past river mile 0.51 (page 3-14). There is limited quantitative data on habitat conditions

in Kalama Creek. It appears the stream has low instream wood and infrequent side channels but that other habitat parameters are good.

Yelm Creek and its tributaries have been closed to further appropriation (page 3-22). [The information used to support these closures is unknown.](#)

PHYSICAL PROPERTIES

The Yelm subbasin is one of the flattest subbasins in the WRIA (page 2-3). Mean elevation is 410 feet above sea level, ranging from 100 to 640 feet. Precipitation in the subbasin averages around 33 to 45 inches per year (page 2-15).

Geology underlying the Yelm subbasin is dominated by glacial till, undifferentiated glacial drift, and Vashon advance outwash (page 2-10, 5.2-11). Most of the glacial deposits tend to be moderately to highly permeable.

Soils in the Yelm subbasin include 19% soils with high infiltration rates, 20% soils with moderate infiltration rates, 31% soils with slow infiltration rates, and 30% soils with very slow infiltration rates (page 2-7).

STREAMFLOW

[No stream flow records are available for the Yelm subbasin.](#) Hence, the Muck Creek gage was used to estimate streamflow conditions in the Yelm subbasin (page 5.1-6). The Muck Creek gage was chosen because the two subbasins are similar with respect to the geology, slope, and precipitation. A unit-area runoff approach was used to estimate monthly values of the 50 and 90% exceedance flows (Figure 17, page 5-13). Estimated flows in the Yelm subbasin drop to near zero in summer and peak in January and February. Average monthly (50% exceedance flows) range from 1 to 111 cfs.

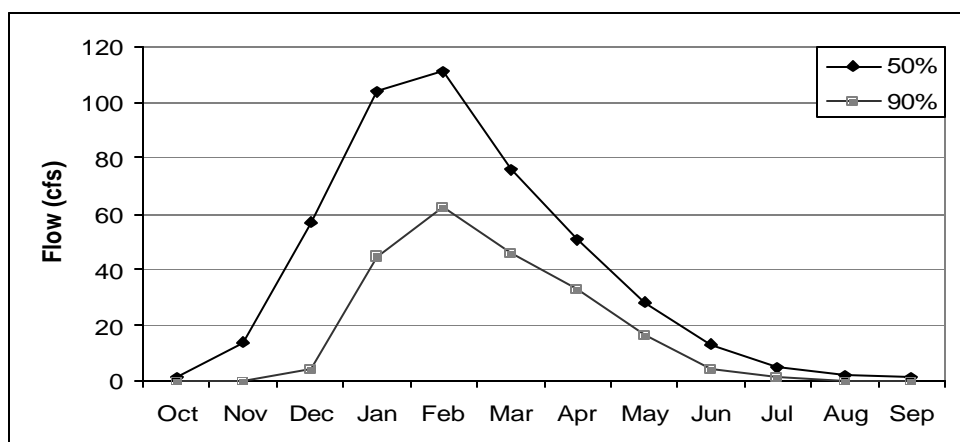


Figure 17. Estimated 50% and 90% exceedance flows for the Yelm subbasin. The 50% exceedance values represent average conditions. The 90% exceedance values represent conditions in relatively dry years.

GROUNDWATER RESOURCES

Information regarding groundwater resources was compiled from data presented in various USGS and private consulting reports, the City of Yelm, and water purveyor information. [This information includes summaries of the results of the USGS model that was discussed earlier.](#)

One of the water bearing hydrogeologic units underlying the Muck/Murray subbasin is the unit coded Qc (page 5.3-11). This unit is extensively used as a source of groundwater. Groundwater tends to be confined in this unit. The subbasin is also generally underlain by a substantial thickness of sediments deposited by glaciers that contain several aquifers. These sediments and their aquifers may extend into adjacent watersheds (page 5.2-12).

Annual groundwater recharge through precipitation is estimated as 22.3 to 24.9 inches per year (page 5.2-15). Lakes, streams, and wetlands may provide for substantial recharge in the subbasin.

The City of Yelm has three production wells located in the subbasin. The source of supply for the City are wells that have been documented to be hydraulically connected to the springs that flow into Yelm Creek and subsequently into the Nisqually River. The wells are reported to be within a shallow unconfined aquifer that is referred to as the Casavent Aquifer (page 5.2-17). The elevation of groundwater in the aquifer is approximately 300 to 310 feet in the immediate vicinity of the wells and likely flows to the north and/or northwest, toward the Nisqually River (page 5.2-19).

The City of Yelm currently operates a wastewater reclamation project that returns Class A reclaimed water to surface water and groundwater systems in the immediate vicinity of the City (page 5.2-17). The Class A reclaimed wastewater is used as direct augmentation of surface water flow, as summer irrigation water, and as groundwater recharge. The wastewater project provides approximately 56 acre-feet of increased groundwater recharge annually to the shallow aquifer system in the immediate vicinity of the City. An additional 168 acre-feet per year of treated wastewater is used to augment surface water flows.

The Yelm subbasin receives approximately 43 inches of precipitation annually with roughly 52 to 58% ending up as groundwater recharge. Estimates of allocated water rights in the subbasin have been estimated at approximately 1.1 inches per year (page 5.2-46). The net depletion of surface water resources in the Yelm subbasin due to residential use was estimated at 0.21 inches for the year 2000 and 0.32 for the year 2020 (page 5.2-46). Overall net depletion to water resources in the Yelm subbasin due to the currently allocated water rights comprises approximately 5% of the estimated groundwater recharge in the basin (page 5.2-46).

WATER RIGHTS AND WATER USE

Water Right Permits, Certificates, and Applications

There are 180 water rights in the Yelm subbasin; 93% of these are certificates (page 5.3-7). By volume, the largest allocation of water was for hydropower purposes followed by irrigation and then multiple domestic water use. The City of Centralia holds the two power rights, a 1927 right for 720 cfs and a 1989 right for 80 cfs. These are non-consumptive rights. The annual volume limitation of the latter right is 58,000 acre-feet, an amount of water substantially higher than any other use in this subbasin (page 5.3-67). The City of Centralia also holds a non-consumptive fish production right for 3.0 cfs.

The City of Yelm currently has three water rights certificates with an annual volume limitation of 613 acre-feet and a combined instantaneous ground water withdrawal rate of 1,700 gallons per minute (gpm) (page 5.3-68). A pending change (CG2-22969) from a certificate appears to be a transfer from stock, irrigation, and domestic use to municipal use for an additional 84.4 acre-feet. The actual acre-feet of water available to Yelm, per Ecology, is 564 acre-feet. Yelm's records indicate 676 acre-feet. The difference has yet been reconciled with the Ecology. An additional four water right applications are on file for 8,500 gpm and pending.

There are 2,677 acres associated with irrigation water rights in the subbasin. Groundwater is the designated source for nearly 80% of these potentially irrigated acres. Actual water use under these irrigation rights may be much smaller than the allocated volumes.

Groundwater appears to be the predominant source of allocated water supply in the subbasin (Figure 18), excluding the large hydropower rights (page 5.3-68). The total allocation of groundwater rights is 29,855 gpm (66.49 cfs). The total allocation of surface water is 9.45 cfs (6.1 million gallons per day).

[Further investigation of groundwater and hydraulic continuity is warranted in this subbasin to determine the net effect of groundwater pumping on the surface water source.](#)

Water Use

The population of the Yelm subbasin in the year 2000 was estimated at 11,288 people. Based on the estimated average day demand of 155 gallons per capita per day (gcd) and the maximum day demand of 155 gcd, the winter season residential demand for this subbasin was approximately 2.6 cfs (1.7 million gallons per day) and the summer season demand was 5.3 cfs (3.4 million gallons per day)(page 5.3-73). Once return flow has been accounted for, the estimated net depletion of water from winter and summer residential water use is 0.34 cfs and 1.48 cfs, respectively.

The Yelm subbasin is the source of water supply for 76 public water systems serving 7,186 people (page 5.3-73). In addition, there are 111 non-residential connections. There are an estimated 3,867 people that are self-supplied under either a multiple domestic right

or an exempt well (page 5.3-74). Some of the multiple domestic rights may be associated with a public water system.

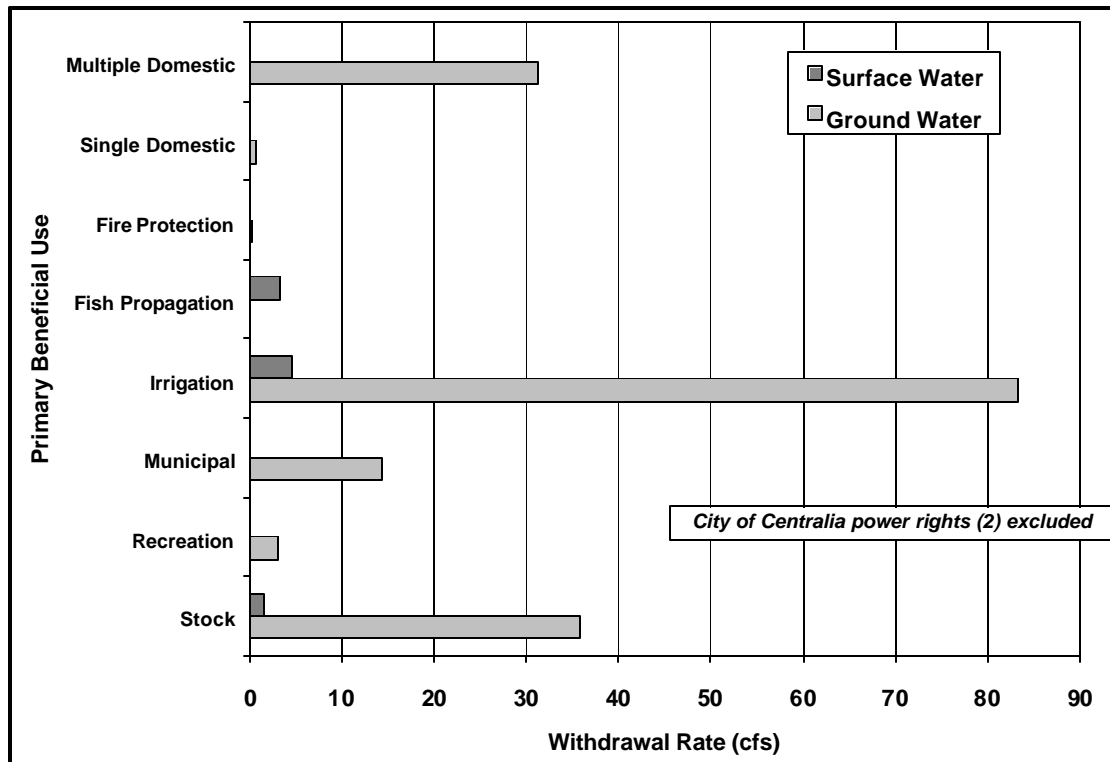


Figure 18: Allocated Diversion/Withdrawal Rate by Primary Beneficial Use for the Yelm subbasin

As was mentioned earlier, the City of Yelm has developed a reclamation project to treat wastewater to a Class A standard. The reclaimed water is used as groundwater recharge, augmentation of surface water, and summer irrigation to offset the use of potable water. Currently, year-round surface water augmentation or return flow totals about 150,000 gallons per day (~118 acre-feet). During the summer, consumptive use of reclaimed irrigation water is roughly 50 acre-feet.

Comparison of Streamflow and Allocated Water

The comparison of streamflow and allocated water is based on the water rights that have been awarded (certificates and permits). While the City of Yelm has a reuse program in place, Ecology has yet to provide them with credits for the reuse of their water supply (page 5.3-74). In that light, the comparison deals only with the water rights and not with the actual use or actual reuse of water.

Allocated water exceeds or very nearly exceeds streamflow at both the 50% and 90% values from July through October (page 5.3-75, Figure 19). The apparent over allocation in this basin is in part due to the low to nonexistent summer flows primarily at the 90%

exceedance level. Streamflow used in this level 1 analysis were not adjusted to account for upstream diversions; hence, that actual volume of water available is likely under-represented. The apparent situation is further overstated since groundwater rights were also included in this calculation and are assumed to be directly connected to surface water flows. More detailed investigation of the extent of surface water capture from groundwater pumping and improved estimates of natural streamflow may be warranted for this basin. Additionally, the Yelm subbasin has a large amount of allocated water for irrigation purposes. As was discussed earlier, estimates of actual irrigation use could be refined. This would improve the estimate of water use.

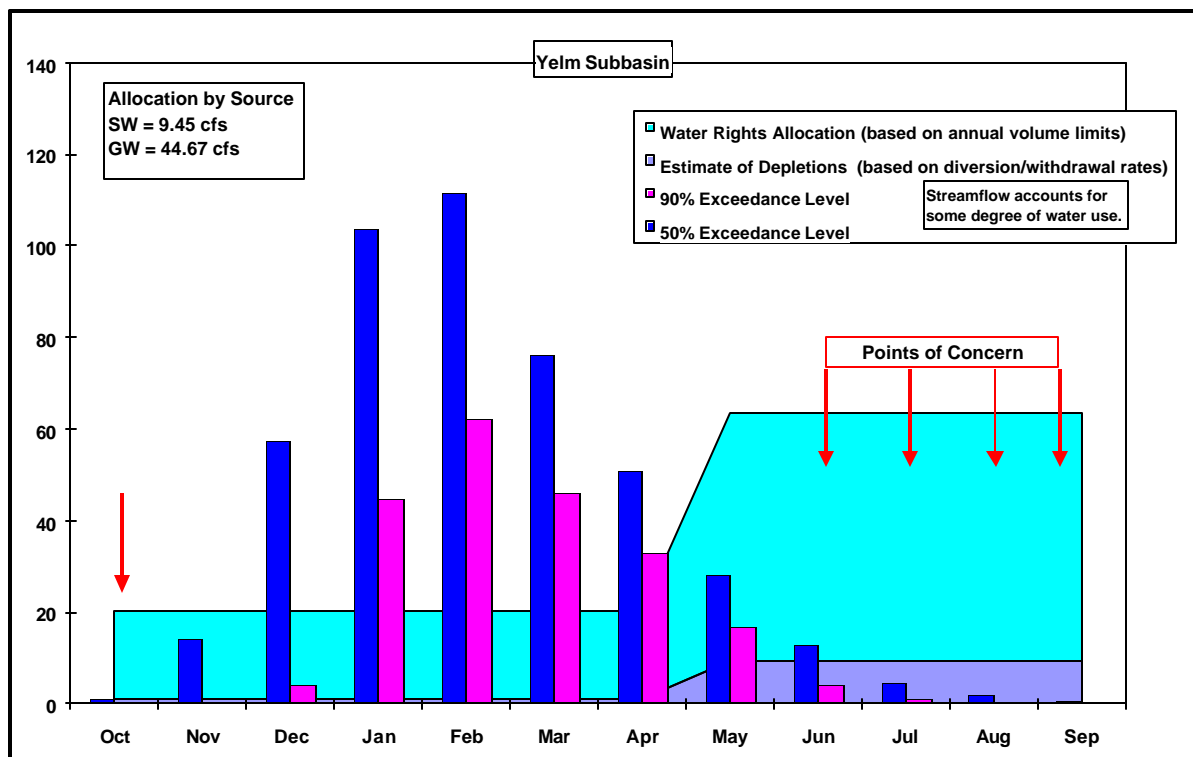


Figure 19. Yelm Subbasin – Streamflow (cfs) vs. Water Allocation and Estimated Depletions to Water Rights.

WATER QUALITY

Dissolved oxygen and stream temperature in Yelm Creek meets state standards (page 4-10). The fecal coliform bacteria standard is exceeded 15 to 18% of the time during summer and winter (page 4-11). Non-commercial farms and a beef cattle operation in the lower reaches of this stream have been suggested as possible pollutant sources. This source likely contributes to the elevated ammonia concentrations as well. The quality of groundwater has been extensively monitored in the Yelm subbasin. None of the wells tested within the Yelm subbasin had nitrate concentrations near the drinking water

standards (page 4-32). However, Thurston County has identified three locations where nitrates are elevated, though meet the standard (page 4-33). These include a site southeast of the City of Yelm, a site near the headwaters of Yelm Creek, and a site north and northeast of Lawrence Lake. Chloride levels are within state standards (page 4-34).

DATA GAPS AND LEVEL II RECOMMENDATIONS

Primary data gaps and recommendations (pages 7-1 to 7-14) for the Yelm subbasin include:

- Improve estimates of natural stream flow.
- Improve estimates of actual irrigation water use.
- Review the AGI/CDM groundwater model once complete. Update groundwater assessment as appropriate. Explore the potential to use the available models to provide a more detailed quantitative spatial analysis of groundwater in the subbasin and the effects of groundwater withdrawals on stream flow. Additional groundwater assessment may be needed to determine the volume of groundwater available for future community needs, factoring in the City of Yelm's reclaimed water system.
- Establish a permanent stream gage upstream of Crystal Springs and a permanent or temporary gage near the mouth of Yelm Creek.
- Explore the data used to support the closures to further allocation. If data is found to be inadequate, evaluate the instream needs of fish to determine if further allocation can be supported.
- Improve on fish habitat data for the Creek upstream of the City of Yelm.
- Add enterococci bacteria to the water quality monitoring parameters to allow for evaluation against the new water quality criteria.

TOBOTON/POWELL/LACKAMAS

Toboton, Powell, and Lackamas Creeks are small tributaries to the Nisqually that drain approximately 27.8 square miles in total (Page 1-3). The subbasin is characterized by a number of lakes including Clear, Elbow, and Bald Hills Lakes (page 4-11). Powell Creek may be seasonally affected by discharge from Elbow Lake and there is a notable ponded wetland system within the lower reach.

LAND USE

Land use in the Toboton/Powell/Lackamas subbasin is primarily rural residential and forestry (Figure 20, page 2-24). Two small dams are present in the subbasin (page 2-27). These are owned by Weyerhaeuser Corporation and were built in 1972.

FISH AND FISH HABITAT

Due to the short length and intermittent nature of the streams in the Toboton/Powell/Lackamas subbasin, limited fish habitat is available (page 3-14). Nevertheless, populations of coho, steelhead, and cutthroat trout are found in these creeks. Juvenile chinook may also use these streams for rearing or refuge. Intermittent summer flows and beaver dams on the creek may block fish access to Lackamas and Toboton Creeks. Powell Creek has a barrier to upstream fish passage at river mile 2.2. Toboton and Powell Creeks have low instream wood and poor riparian conditions.

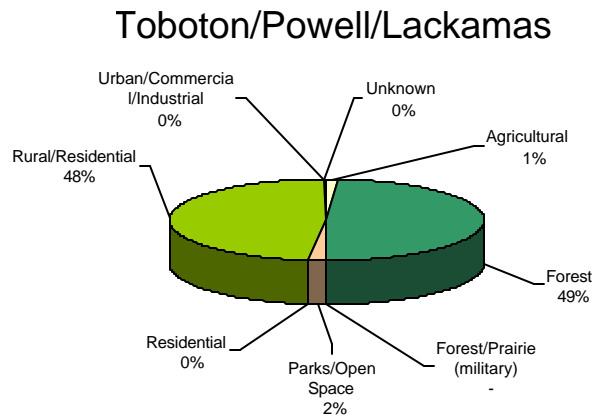


Figure 20. Land Use in the Toboton/Powell/Lackamas subbasin

Toboton and Lackamas Creeks and their tributaries are closed to further water appropriations from April 1 to November 30 (page 3-21). [The quality of the information used to support those closures is unknown.](#)

PHYSICAL PROPERTIES

Mean elevation of the Toboton/Powell/Lackamas subbasin is 808 feet above sea level. Average basin gradient is 19% and elevations range from 340 to 2,035 feet (page 2-3). Precipitation in the subbasin averages around 33 to 45 inches per year (page 2-15).

Geology underlying the Toboton/Powell/Lackamas subbasin is diverse. Volcanic and glacial deposits underlie the majority of the basin, however glacial outwash and alluvium are also common (page 2-10). The volcanic material is predominately found on the eastern side of the subbasin (page 2-9). Roughly, 92% of the soils in the Toboton/Powell/Lackamas subbasin are considered to have slow to very slow infiltration rates (page 2-7).

STREAMFLOW

[No stream flow records are available for the Toboton/Powell/Lackamas subbasin.](#) Hence, the Ohop Creek gage was used to estimate streamflow conditions in the Toboton/Powell/Lackamas subbasin (page 5.1-6). The Ohop Creek gage was chosen because the two subbasins have similar slope and geology. [Mean annual precipitation in the Toboton/Powell/Lackamas subbasin is approximately \$\frac{3}{4}\$ of what occurs in the Ohop](#)

basin. Consequently, streamflow statistics calculated using the Ohop Creek gage might be overestimated (page 5.1-7).

A unit-area runoff approach was used to estimate monthly values of the 50 and 90% exceedance flows (Figure 21, page 5-13). Average monthly (50% exceedance flows) range from 9 to 100 cfs.

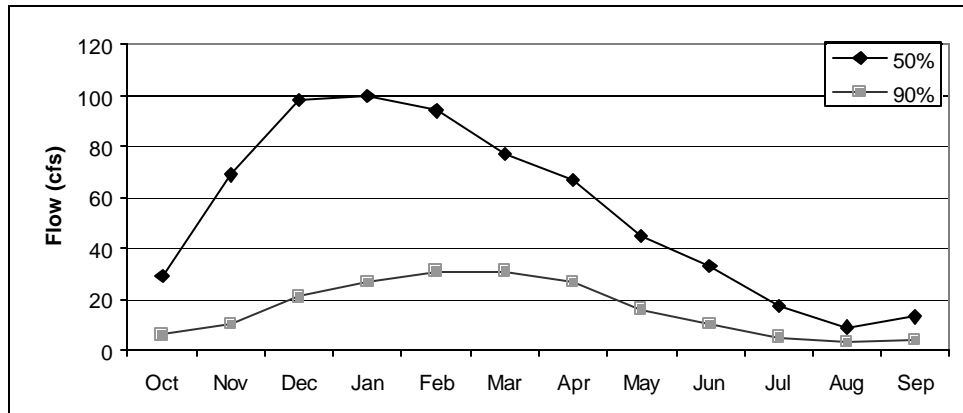


Figure 21. Estimated 50% and 90% exceedance flows for the Toboton/Powell/Lackamas subbasin.

GROUNDWATER RESOURCES

Detailed regional hydrogeologic studies have not been completed in the Toboton/Powell/Lackamas subbasin (page 5.2-7). Therefore, the understanding of the regional hydrogeology is limited to information available on water well reports and various consulting reports for well installations.

Groundwater characteristics of the western half of the subbasin can be inferred from information on similar areas to the west. Much of the eastern area in the subbasin is underlain by bedrock. Aquifers in these areas are limited to small areas near the fractures and joints in bedrock (page 5.2-12). The western end of the subbasin has areas of coarse-grained deposits (Qc), which can support highly productive wells (page 5.2-11). *Little is known about the depth or direction of groundwater flow in this subbasin.* Flow direction is likely northwestward, flowing towards the mainstem Nisqually (page 5.2-18).

Approximately 39 to 42% of the annual precipitation is estimated to contribute to groundwater recharge (page 5.2-46). Annual groundwater recharge is estimated in the range of 15.2 to 16.4 inches, which is the lowest recharge rate in the entire lower Nisqually watershed (page 5.2-15). *The estimates of recharge may not be accurate due to the large amount of bedrock in the subbasin and the lack of adequate information on surface water runoff.* Water rights in the subbasin have been estimated at 0.23 inches per year. Therefore, current allocated surface/groundwater rights could comprise approximately 1.5% of the estimated groundwater recharge in this subbasin. Little

increase is projected to the year 2020. Therefore, the potential influence of water use on recharge and streamflow is low at the watershed scale in this subbasin.

WATER RIGHTS AND WATER USE

Water Rights

There are 28 water rights in the Toboton/Powell/Lackamas Subbasin of which 75% are certificates (Figure 22, page 5.3-79). Four groundwater applications are pending and one change to a groundwater right has been issued. The Clearwood Community Association holds the largest groundwater certificate for 425 gpm and 529 acre-feet. Clearwood has also submitted an application for 1,000 gpm to serve 1,355 domestic units, the largest of the ground water applications.

The largest surface water right (1.20 cfs) is designated for wildlife, recreation, and fish production and is non-consumptive (page 5.3-79). The next largest right is for 0.5 cfs intended for wildlife, power, fisheries, irrigation of 2 acres, and a single domestic supply.

There are 197 acres covered under irrigation rights. Surface water is the source of supply for most of these. There is little actual irrigation occurring in this subbasin.

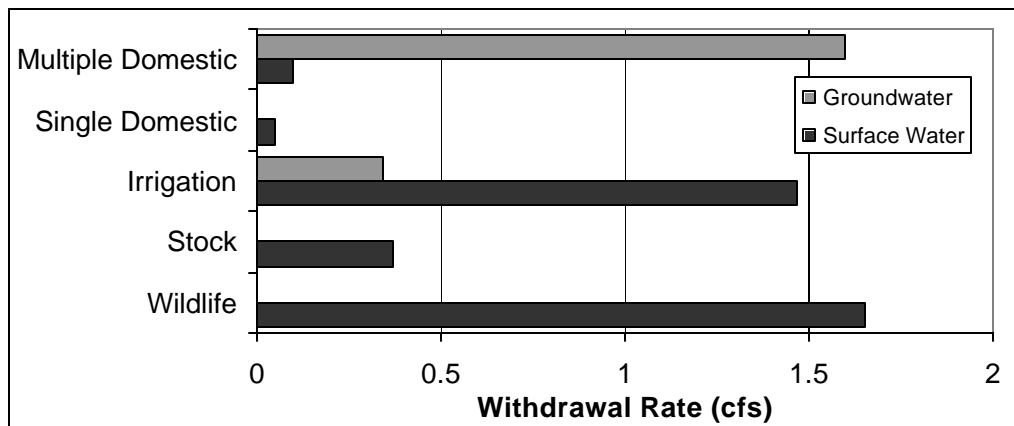


Figure 22. Allocated Diversion/Withdrawal Rate (cfs) by Primary Beneficial Use in the Toboton/Powell/Lackamas Subbasin.

Water Use

In the year 2000, the population in the Toboton/Powell/Lackamas Subbasin was 1,591 people, the lowest population of the six subbasins for the Lower Nisqually Basin. The demand for water ranges from 0.39 cfs (252,063 gallons per day) in winter to 0.77 cfs (497,664 gallons per day) in summer. Once return flow is accounted for, the net water depletions from residential water use range from about 0.05 cfs in the winter to 0.22 cfs in the summer months.

The Toboton/Powell/Lackamas subbasin is the source of water supply for seven public water systems serving 1,327 people (page 5.3-86). In addition, there are 970 non-

residential connections. About 240 people in the Toboton/Powell/Lackamas Subbasin are on exempt wells or under multiple domestic rights.

Comparison of Streamflow and Water Allocation

Comparison of the streamflow to allocated water in this subbasin suggests that depletions are substantially lower than the 90% exceedance flow (page 5.3-88, Figure 23). Allocations appear to be greater than the 90% exceedance flow in the summer months. However, groundwater rights were included in the assessment although groundwater sources were not. Hence, the magnitude of the difference between water available and water allocated is overestimated.

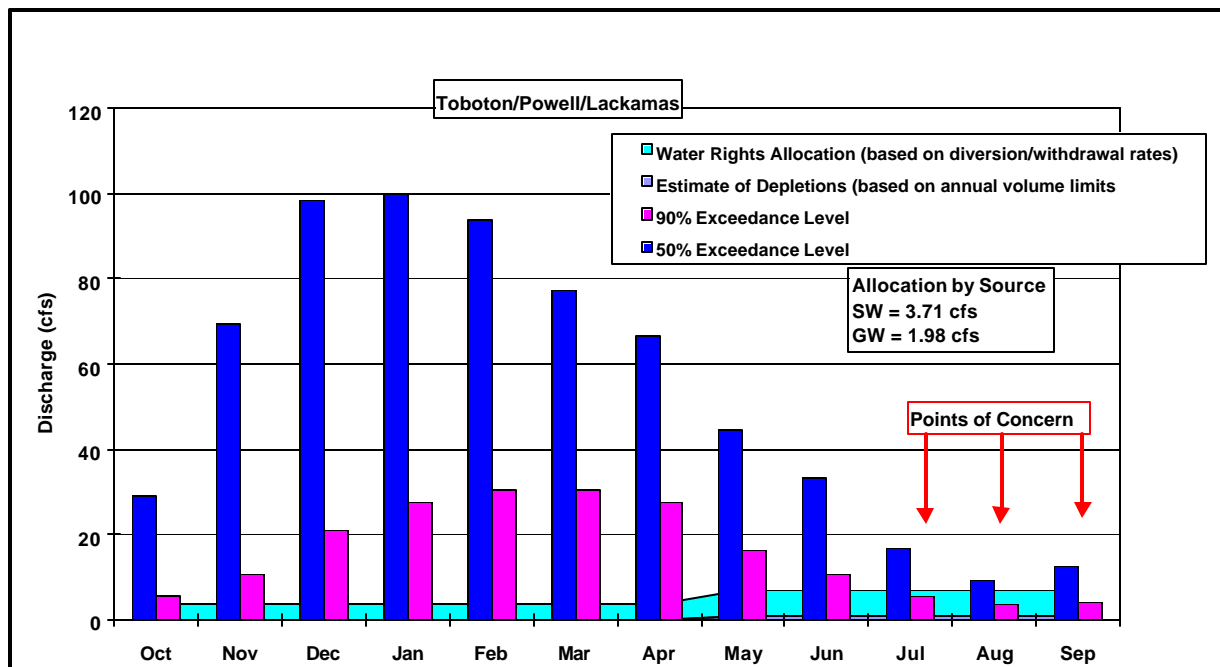


Figure 23. Streamflow vs. Water Allocation and Estimated Depletions to Water Rights in the Toboton/Powell/Lackamas Subbasin.

WATER QUALITY

There is little water quality data available for streams in the Toboton/Powell/Lackamas subbasin. No fecal coliform data are available for these streams (page 4-12). Other water quality criteria are apparently met in Toboton Creek (page 4-13).

Lackamas Creek meets the water quality criteria for temperature and for dissolved oxygen in winter. In summer, however, dissolved oxygen levels are not met 50% of the time, although levels are not far below the standard (page 4-13). Dissolved oxygen concentrations in Powell Creek fail to meet the state standards 100% of the time during the summer and occasionally during the winter. The mean summer concentration is well below the water quality standard (page 4-13). The stream temperature criterion is also exceeded occasionally in Powell Creek. This and the lower dissolved oxygen

concentrations in this stream are likely a reflection of the ponded wetland that provides the major water source at the sampling site (page 4-12). [Information on the quality of groundwater was not available.](#)

DATA GAPS AND LEVEL II RECOMMENDATIONS

There are several data gaps in the Toboton/Powell/Lackamas subbasin. In the near term, filling these gaps may be a lower priority given the relatively low water demand in the basin. The top priority gaps and recommendations (pages 7-1 to 7-14) include:

- [Establish temporary stream gages at the mouths and upstream of the spring flow in the lower portions of Powell and Toboton Creeks. The value of these gages is diminished if the Tanwax Creek gage is not re-established.](#)
- [Include monitoring of fecal coliforms and enterococci bacteria in water quality sampling.](#)

TANWAX /KREGER/OHOP

Tanwax Creek, Kreger Creek, and the Ohop River are tributary to the Nisqually River and cumulatively drain an area approximately 82.1 square miles (page 1-3). Tanwax Creek drains approximately 27 square miles and is greatly influenced by lakes and wetlands. Ohop Creek is the second largest tributary to the Nisqually below LaGrande Dam. It drains 44 square miles. Lynch Creek and Twenty-five Mile Creek are its main tributaries. Ohop Lake, lies on Ohop Creek. It is the largest natural lake in the Nisqually Basin with a surface area of 235 acres. In 1889, 30 % of the stream flow in the Ohop River was diverted into the Puyallup Basin to protect the lower Ohop Valley from flooding (page 2-1). The town of Eatonville discharges its stormwater collection into Lynch Creek.

LAND USE

Land use in the Tanwax/Kreger/Ohop subbasin is dominated by rural residential developments (63%) and forestry (29%) (Figure 24, page 2-24). A small amount of agricultural land is also present in the basin. Dams in the subbasin include the Tanwax Lake dam, built in 1920, and the Lindstrom Dam on Kapowsin Creek, which was built in 1965 (page 2-27).

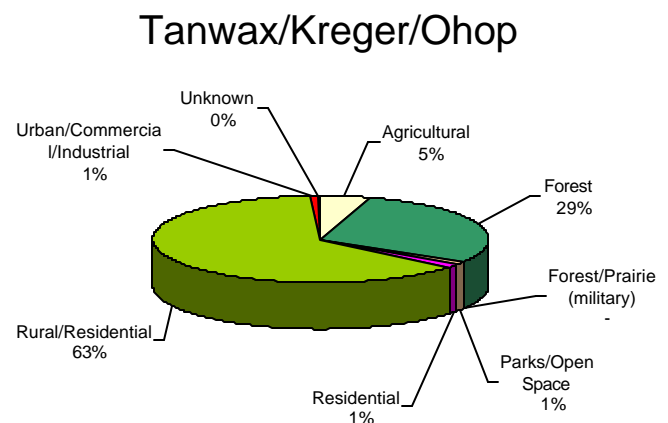


Figure 24. Land use in the Tanwax/Kreger/Ohop subbasin.

FISH AND FISH HABITAT

Lower Ohop Creek is home to populations of coho, chinook, pink, winter steelhead, and coastal cutthroat. It is the third largest tributary accessible to anadromous fish in the basin (page 3-13). Upstream of river mile 0.3, riparian conditions are generally very poor and downstream of that point, riparian areas are dominated by hardwoods. Instream wood is generally low, reflecting the poor condition of the riparian areas. The creek is channelized with a bottom that is too sandy and silty to support good survival of salmon and trout eggs. The sandy condition is at least partially due to low stream gradients. The town of Eatonville discharges its stormwater collection into Lynch Creek, a tributary to the Ohop, which contributes to the high sediment loads. Fine-grained soils and other land management also contribute to these loads.

Tanwax Creek also has the potential to provide significant fish habitat (page 3-12). Currently it supports a number of salmonid species. Riparian conditions are poor in most of the lower river and wetlands have been invaded by reed canary grass.

Tanwax Creek and its tributaries are closed April 1 through October 31 to further water allocation (page 3-21). Ohop Creek is closed year round and Ohop Lake has restrictions on draw down (page 3-22). [The information used to support these closures is unknown.](#)

PHYSICAL CHARACTERISTICS

Mean elevation of the Tanwax/Kreger/Ohop subbasin is 1,060 feet above sea level. Average basin gradient is 16% and elevations range from 360 to 3,720 feet (page 2-3). Precipitation in the subbasin increases with elevation (page 2-14). At lower elevations, rainfall ranges from 33 to 45 inches per year (page 2-15). At the higher elevations, rainfall is in the range of 65 to 75 inches per year.

Geology underlying the subbasin is diverse. Volcanic and glacial deposits underlie the majority of the basin (page 2-10). The volcanic material is predominately found on the eastern side of the subbasin (page 2-9). [Little digital soil data is available for the subbasin.](#) Soils over much of the area are expected to be of low to very low permeability (page 2-7).

STREAMFLOW

The Ohop Creek gage (#12088000) was used to represent streamflow conditions in the Tanwax/Kreger/Ohop subbasin (page 5.1-6). The gage is located downstream of all major tributaries. Approximately 2/3 of the data was collected during periods of cool/wet weather and the remainder was collected during periods of warm/dry weather. Consequently, streamflow statistics calculated using this gage record should approximate average conditions. Monthly values of the 50 and 90% exceedance flows were calculated (Figure 25, page 5-13). Average monthly (50% exceedance flows) range from 27 to 295 cfs.

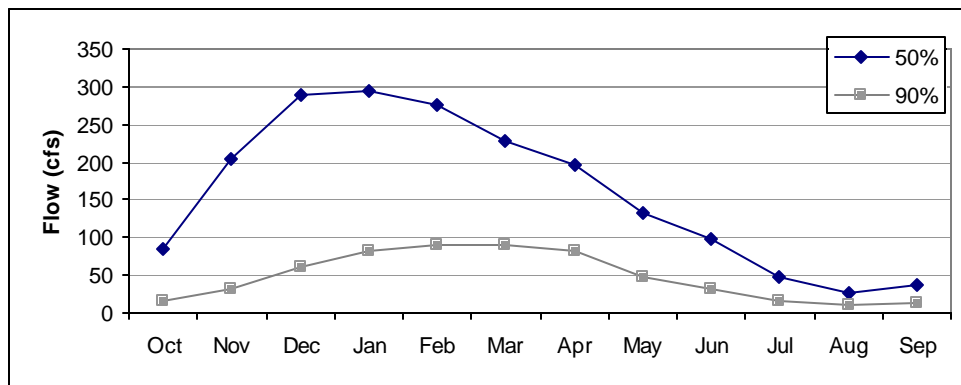


Figure 25. Estimated 50% and 90% exceedance flows for the Tanwax/Kreger/Ohop subbasin.

GROUNDWATER RESOURCES

Groundwater characteristics of the western half of the subbasin can be inferred from information on similar areas to the west. [Detailed regional hydrogeologic studies have not been completed in the Tanwax/Kreger/Ohop subbasin \(page 5.2-7\).](#) Therefore, the understanding of the regional hydrogeology is limited to information available on water well reports and various consulting reports for well installations.

Much of the eastern area in the subbasin is underlain by bedrock. Aquifers in these areas are limited to small areas near the fractures and joints in bedrock (page 5.2-12). The western end of the subbasin has areas of coarse-grained deposits, which can support highly productive wells. [Little is known about the depth or direction of groundwater flow in this subbasin.](#) Groundwater likely flows towards the mainstem Nisqually River (page 5.2-18).

Annual groundwater recharge is estimated in the range of 16.6 to 23.3 inches (page 5.2-15). [The estimates of recharge may not be accurate due to the large amount of bedrock in the subbasin and the lack of adequate information on surface water runoff.](#) Approximately 36 to 51% of the annual precipitation is estimated to contribute to groundwater recharge (page 5.2-46). Water rights in the subbasin have been estimated at approximately 0.14 inches per year. Therefore, current allocated surface/groundwater rights could comprise approximately 0.8% of the estimated groundwater recharge in this subbasin. Therefore, the potential influence of water use on recharge and streamflow is low at the watershed scale in this subbasin.

WATER RIGHTS AND WATER USE

Water Rights

There were 157 water rights on file with WDOE in the Tanwax/Kreger/Ohop Subbasin (Page 5.3-89). The total allocation under certificates and permits was 10.46 cfs for surface water and 918 gpm (2.04 cfs) for ground water (page 5.2-89). The largest right in

the basin is a surface water certificate for 2.40 cfs to irrigate 120 acres. The largest groundwater right was a multiple domestic right for the Clear Lake Water District for 150 gpm and 59 acre-feet/year, which is the largest public water system in this subbasin.

The beneficial use sector with the highest volume of allocated water was irrigation. Irrigation rights cover 679 acres and allocate the use of 1,257 acre-feet/year (page 5.3-89). Irrigation uses account for 81% of the total allocated volume of water in the subbasin (Figure 26). Surface water rights represent 87% of the total annual volume allocation.

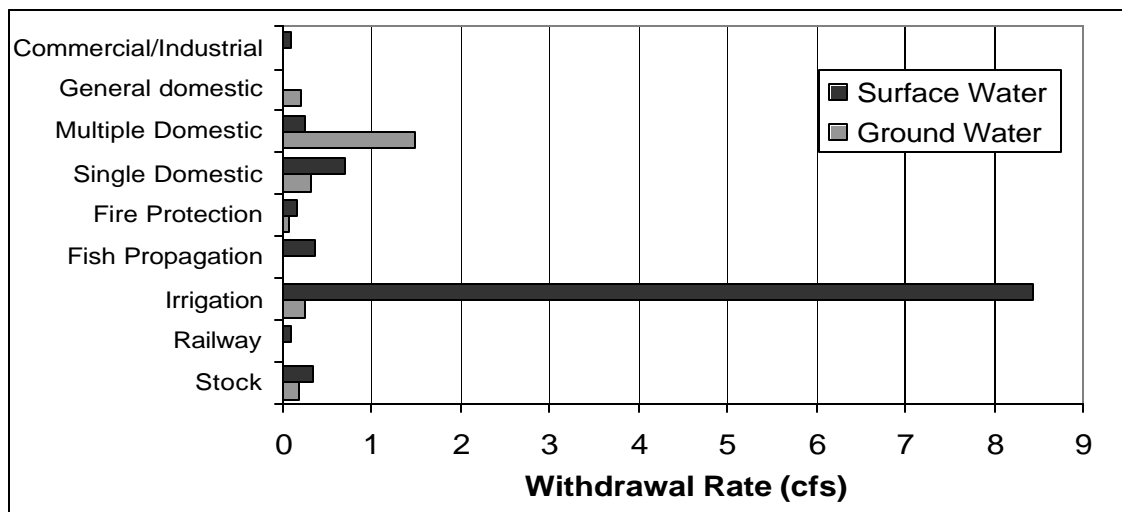


Figure 26. Allocated Diversion/Withdrawal Rate (cfs) by Primary Beneficial Use in the Tanwax/Kreger/Ohop Subbasin.

Water Use

The total population in the Tanwax/Kreger/Ohop Subbasin in the year 2000 was 4,571. The water demand was estimated to be 1.01 cfs (652,780 gallons per day) in winter and 2.02 cfs (1.3 million gallons per day) in summer (page 5-3.97). The net depletion of water resources is roughly 0.13 cfs in winter and 0.57 cfs in summer.

The Tanwax/Kreger/Ohop subbasin is the source of water supply for 61 public water systems serving 972 people, or 21% of the total population (page 5.3-97). One of the users is Northwest Trek Wildlife Park in the Clear Lake Area, which serves about 160,000-200,000 visitors a year. The Park has a 600' deep well that supplies drinking water and pumps water from Horseshoe Lake to various exhibits.

Comparison of Streamflow and Water Allocation

The depletions in this subbasin have a minor effect on the surface water system (page 5.3-100, Figure 27). In addition, the streamflow in this subbasin more closely approximates natural flow than in other subbasin since the use from the system is minor.

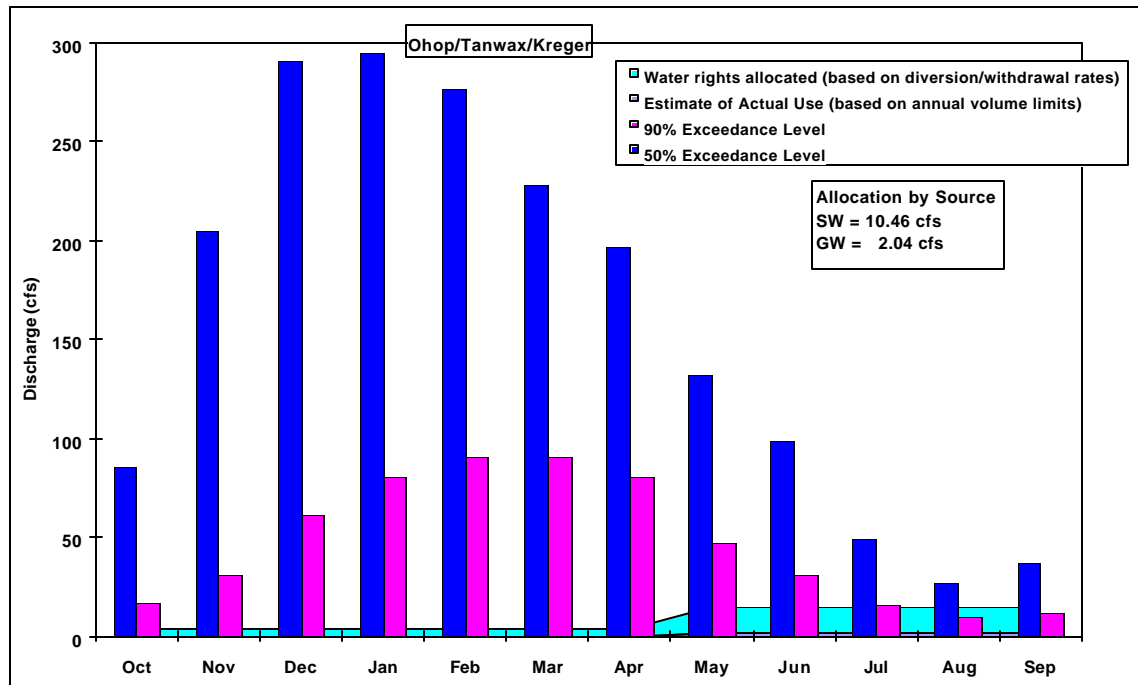


Figure 27. Streamflow vs. Water Allocation and Estimated Depletion to Water Rights for the Tanwax/Kreger/Ohop Subbasin.

WATER QUALITY

Water quality information is available from two sites on Tanwax Creek and three sites on Ohop Creek (page 4-14). One of the Ohop Creek sites is just downstream of Ohop Lake. [No water quality data is available for Kreger Creek. Information on the quality of groundwater was not available for this subbasin.](#)

Dissolved oxygen levels at the upper site of Ohop Creek meet state criteria (page 4-15). The temperature criteria, however, is exceeded slightly 8% of the time. At the site downstream of the lake, dissolved oxygen and temperature do not meet water quality standards greater than 50% of the time during summer (page 4-15). Maximum stream temperatures and minimum dissolved oxygen levels recorded at this site are both within the typical lethal range for fish. The water quality situation here likely reflects the discharge of warm water with low oxygen concentrations from the lake (page 4-17). Such conditions are common downstream of lakes. Dissolved oxygen concentrations and temperature levels improve downstream of river mile 6.0. However, both dissolved oxygen criteria and temperature criteria are violated frequently at river mile 0.2. Fecal coliform levels are also quite high in summer at all stations on Ohop Creek, as are sediment loads (page 4-15, page 4-17). During summer, agricultural activities contribute to sediment and fecal coliform levels. In winter, sediment largely originates from Lynch Creek.

Water quality at the upper station of Tanwax Creek appears to be greatly influenced by the lake outflow (page 4-16). Summer dissolved oxygen levels are extremely low,

however temperature meets state criteria. Dissolved oxygen concentrations recover between the upper and lower stations and easily meet the water quality standard at the lower station. Conversely, temperatures are higher at the lower station, exceeding the state criteria 39% of the time. Fecal coliform bacteria standards are occasionally exceeded in both summer and winter.

DATA GAPS AND LEVEL II RECOMMENDATIONS

Water withdrawals are relatively small in the Tanwax/Kreger/Ohop subbasin. Therefore, the need to fill data gaps may be low in the near term. However, future water demand in the area may increase the importance of filling those data gaps. Top priority gaps and recommendations (pages 7.1-7.14) for the subbasin include:

- Little is known about groundwater resources in the subbasin. Efforts to describe the major hydrogeologic units may be merited. Preliminary studies to evaluate the connectivity between groundwater and surface water resources may also be useful.
- Ohop Creek contains substantial fish habitat. The stream is closed to further allocations. Instream flow studies in the subbasin may help to identify the quantity of water necessary to protect aquatic resources.
- Bull trout may be present in the subbasin. Surveys to establish their presence or absence could be conducted.
- Include enterococci in the list of parameters measured in water quality monitoring. Conduct additional monitoring of temperature at the outlet of the lake on Tanwax Creek to determine if the one very low measurement available at that site is representative of the normal condition.

MASHEL

The Mashel Subbasin initiates on the flanks of Mount Rainier and drains an area of 89.2 square miles (page 1-3). It has three major tributaries including Busy Wild Creek and Beaver Creek in the upper reaches and the Little Mashel River in the lower reach. Most of the basin is forested. The Town of Eatonville is located near RM 5.5. The City draws drinking water from the Mashel. Secondarily treated wastewater from Eatonville is discharged downstream of the City. Some agricultural land is located near Eatonville and the Little Mashel River, which discharges to the mainstem just upstream of Eatonville.

LAND USE

Land use in the Mashel subbasin is roughly $\frac{3}{4}$ forestry and $\frac{1}{4}$ rural residential (Figure 28, page 2-24). Minor amounts of other land uses are also present. The most significant municipal area in the subbasin is the City of Eatonville. There are no known dams in the subbasin (page 2-27).

FISH AND FISH HABITAT

The Mashel River is the largest tributary accessible to salmonids in the basin (page 3-9). Coho, chinook, pink, steelhead, and cutthroat populations are supported in the creek. The Mashel River is rip rapped and channelized near Eatonville, between river mile 5.1 and river mile 6.0 (page 3-10). Upstream of river mile 6.6, the riverbanks are unstable and failing in places.

The Little Mashel joins the mainstem Mashel River at river mile 4.4. A

waterfall at river mile 0.8 is impassable. Habitat conditions are generally good but fish use is limited. Beaver Creek enters the mainstem Mashel at river mile 9.3. An impassable cascade at river mile 0.5 limits fish access in upper reaches of the creek. An impassable cascade is also located at river mile 5.0 on Busywild Creek. The abundance of instream wood is low in the Mashel and its major tributaries. Spawning habitat is, however, in relatively good condition.

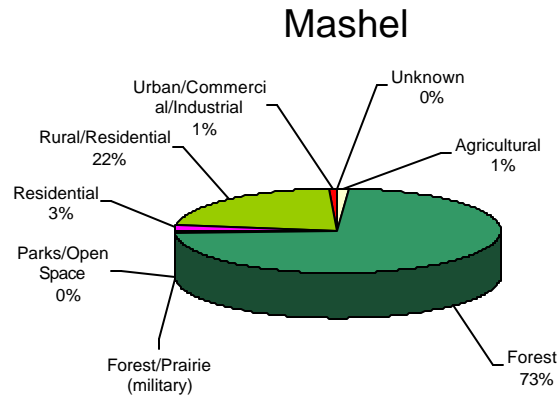


Figure 28. Land use in the Mashel subbasin.

Instream flows have been set for the Mashel River by Ecology. These flows vary seasonally and range between 40 and 100 cfs (pages 3-22 to 3-24). [These instream flows were not based upon studies regarding the relationship between fish habitat and flow.](#)

PHYSICAL CHARACTERISTICS

Mean elevation of the Mashel subbasin is 2,237 feet above sea level. Average basin gradient is 31% and elevations range from 460 to 4,845 feet (page 2-3). Precipitation in the subbasin increases with elevation. At lower elevations, rainfall ranges from 33 to 45 inches per year. At the higher elevations, rainfall is in the range of 83 to 91 inches per year.

Geology underlying the subbasin is mostly volcanic deposits and undifferentiated glacial drift (page 2-10). Digital soil data is available for the roughly 75% of the subbasin. Soils are primarily of low to moderate permeability (page 2-7).

STREAMFLOW

The Mashel River gage (#12087000) was used to represent streamflow conditions in the Mashel subbasin. The gage is located approximately 3 miles upstream from the outlet of the subbasin and is located downstream of all major tributaries (page 5.1-7). Approximately ½ of the data was collected during a cool/wet period and the remainder was collected during a warm/dry period. Consequently, streamflow statistics calculated using this gage record should approximate “normal” conditions. Monthly values of the

50 and 90% exceedance flows were calculated (Figure 29, page 5-13). Average monthly (50% exceedance flows) range from 28 to 494 cfs.

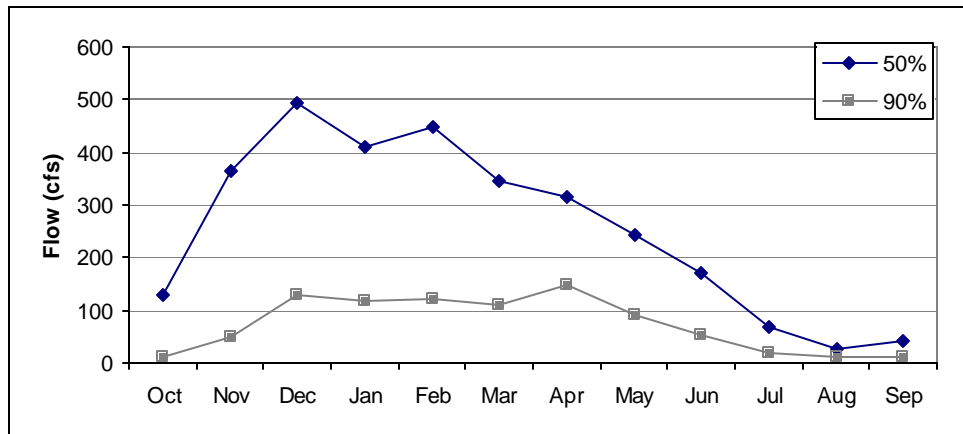


Figure 29. Estimated 50% and 90% exceedance flows for the Mashel subbasin.

GROUNDWATER

Detailed regional hydrogeologic studies have not been completed in the Mashel subbasin (page 5.2-7). Therefore, the understanding of the regional hydrogeology is limited to information available on water well reports and various consulting reports for well installations.

More than 60 percent of the Mashel subbasin was not covered by continental glacial ice. The surficial geology in these areas consists of sedimentary and volcanic bedrock. Aquifers in these areas are limited to small areas near the fractures and joints in bedrock (page 5.2-11). The western end of the subbasin has areas of coarse-grained deposits, which can contain confined aquifers.

Annual groundwater recharge is estimated in the range of 22.5 to 36.9 inches (page 5.2-15). The estimates of recharge may not be accurate due to the large amount of bedrock in the subbasin and the lack of adequate information on surface water runoff. The water balance and water use analysis completed for this Level I assessment indicate that the net depletion to water resources in the Mashel subbasin due to the allocated water rights and net residential use will be less than one percent of the estimated groundwater recharge in the basin through 2020 (page 5.2-48). Therefore, the potential influence of water use on recharge and streamflow is low at the watershed scale in this subbasin.

WATER RIGHTS AND WATER USE

Mashel Subbasin has 43 rights. Since this subbasin is primarily forested, the water use is relatively low (page 5.3-101). There were potentially 175 acres irrigated in this subbasin served by 9 water rights. In addition, there were 22 rights for each of the two categories

of multiple and single domestic use covering 635 acre-feet (Figure 30). Six of the multiple domestic rights use ground water as their source of supply.

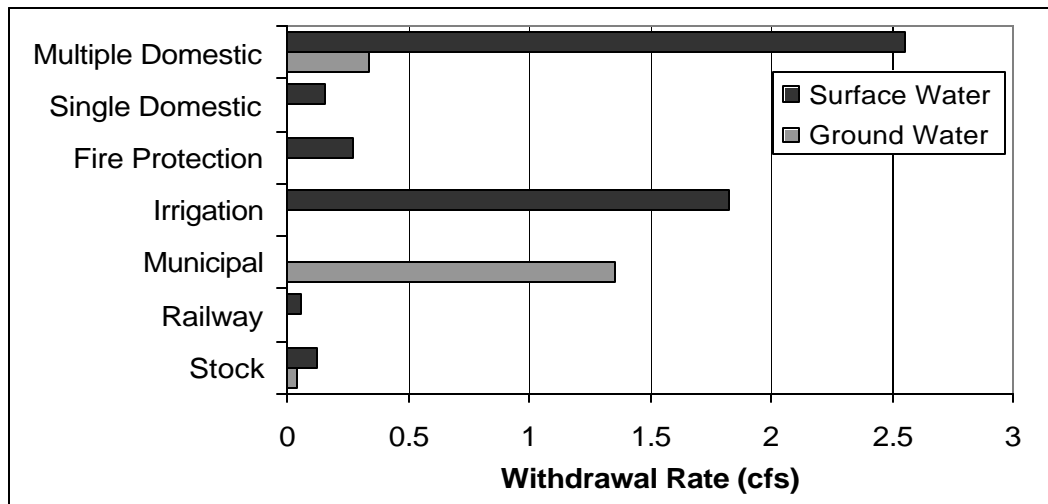


Figure 30. Allocated Withdrawal Rate (cfs) by Primary Use for the Mashel Subbasin.

Tacoma City Light possesses three multiple domestic surface water rights to supply water to the community of LaGrande; the total diversion rate is 0.08 cfs (8 acre-feet annually). The Town of Eatonville holds the largest surface water right for 2.3 cfs (page 5.3-102).

Water Use

Based on the WDOH (1999) demand equation, the average per capita water demand was 119 gallons per day. With the estimated 2000 Mashel population of 2,279, the average total demand was 0.42 cfs (271,453 gallons per day) (page 5.3-107). Estimated net depletions are small at 0.05 cfs. The summer season demand was 0.84 cfs (542,906 gallons per day) with depletions estimated at 0.24 cfs.

The Town of Eatonville straddles the boundary between the Mashel and Ohop Subbasins; however, the source of supply location for the Town is in the Mashel Subbasin. The Town holds three water rights, one surface water right (2.3 cfs and 525 acre-feet), and two ground water rights (610 gpm and 794 acre-feet) (page 5.3-107). Pack Forest, a University of Washington experimental forest, is also located within Mashel Subbasin. There are two community domestic water rights for the facility to supply roughly 100 people per day. The assumed per capita usage noted in the water rights was 125 gallons; the annual volume limit was 19 acre-feet. Of the total subbasin population, roughly 95% are served by a public water system (page 5.3-108).

Comparison of streamflow to allocated water for the Mashel subbasin includes the instream flows set for Mashel River at river mile 3.25 (page 53-108 and 3-20). For this subbasin, the total demand on the surface water system is represented by the combination of the allocated uses and the instream flow. The estimated depletions to the system are small when compared to instream flow (Figure 31).

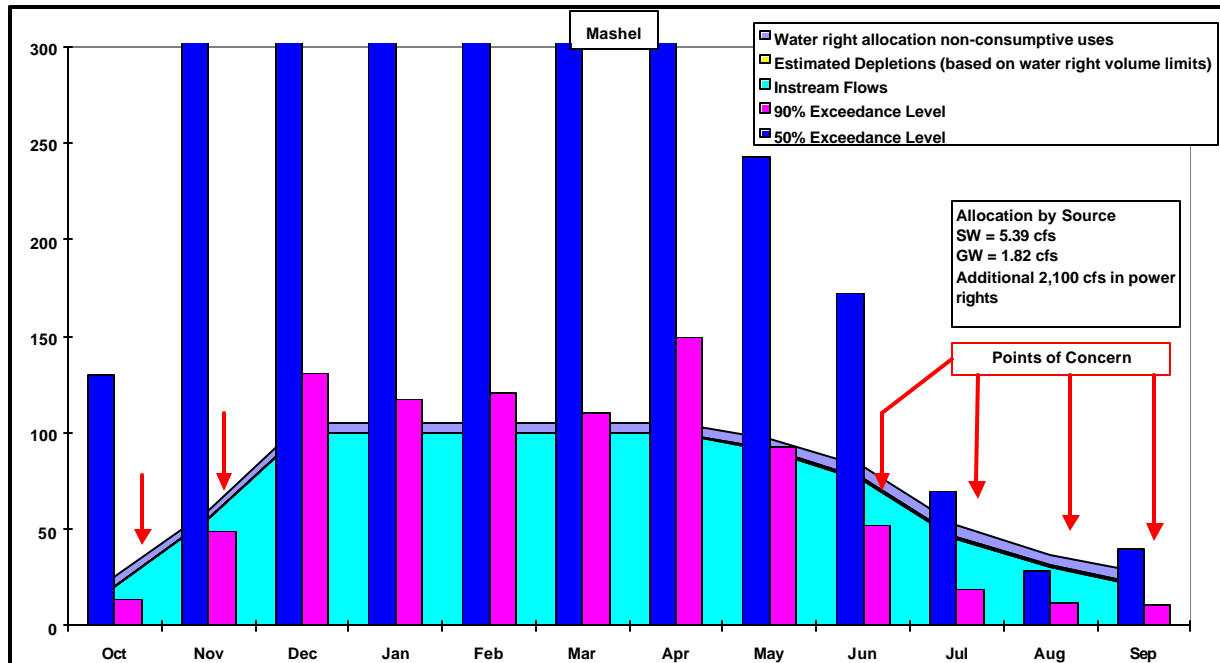


Figure 31. Streamflow vs. Water Allocated and Estimated Depletion from Water Rights in the Mashel Subbasin.

WATER QUALITY

Dissolved oxygen levels in the Mashel subbasin meet state standards (page 4-21). Fecal coliform levels are occasionally exceeded in the lower 3 miles (page 4-21). The state temperature standard is exceeded 30% of the time at the mouth of the river and 18% of the time at RM 60 (page 4-21). This appears to be related to inadequate shade along the stream (page 4-20). Suspended sediment loads and phosphorus are also very high at the mouth (page 4-22). [Information on the quality of groundwater was limited for this subbasin.](#) The only measure of groundwater quality that exceeded the state standard for chloride was taken in the Little Mashel (page 4-35). The site had elevated levels in only one of four measurements.

DATA GAPS AND LEVEL II RECOMMENDATIONS

Estimated depletions associated with water use is very small in the Mashel subbasin. Although there are several data gaps for the subbasin, few would be considered high priority at this time. In the event of future increases in demand, the priorities may change. The highest priority recommendations (pages .1 to 7.14) for the subbasin include:

- [Little is known about groundwater resources in the subbasin. Efforts to describe the major hydrogeologic units and connectivity between groundwater and surface water resources may be merited.](#)

- The Mashel subbasin contains substantial fish habitat. Closer review of the data supporting the instream flow requirements is recommended. Studies supporting the instream flows should be updated or improved if needed.
- Bull trout may be present in the subbasin. Surveys to establish their presence or absence could be conducted.
- Include enterococci in the list of parameters measured in water quality monitoring.